RED STAR VOLUME 17

Early Soviet Jet Bombers

The 1940s and Early 1950s

Yefim Gordon

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Original translation by Dmitriy and Sergey Komissarov

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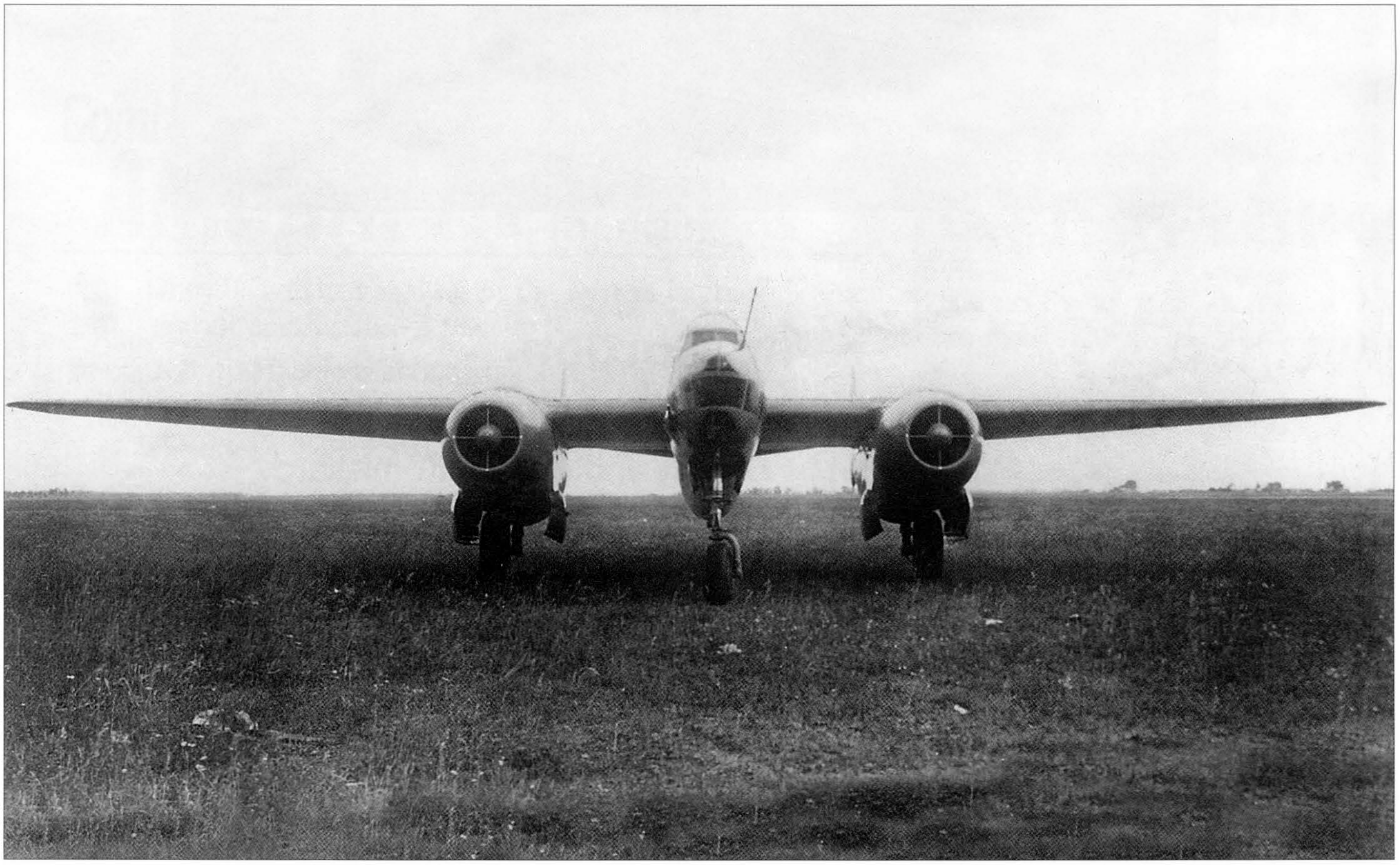
Contents

Introduction **3**
1. The First Ilyushin Jet **9**
2. Myasishchev's Hopes **17**
3. Denied the Chance to Fly – Sukhoi's First Jet Bomber **21**
4. The Junkers Heritage – The Forward-Swept Wing Designs . . **31**
5. Baade's Last Bombers **53**
6. Tupolev's Early Jets **73**
7. The Next Round – Tupolev's Steps Towards Production Bombers **97**
8. IL-28: Soviet Canberra **109**
Line drawings **114**

Title page: The Tupolev Tu-12 seen during manufacturer's tests, still bearing its initial service designation Tu-10 on the nose. Note the bullet-shaped air intake centrebodies mounted on cruciform struts.

Below: A head-on view of the Tu-12, Tupolev's first jet bomber. The aerial mast was canted to port to avoid obstructing the pilot's view.

Front cover: The Ilyushin IL-22 – the Soviet Union's first fully indigenous jet bomber.
Rear cover, top: The Tu-12 during manufacturer's flight tests; bottom: the 'Tupolev '73' prototype.



Introduction

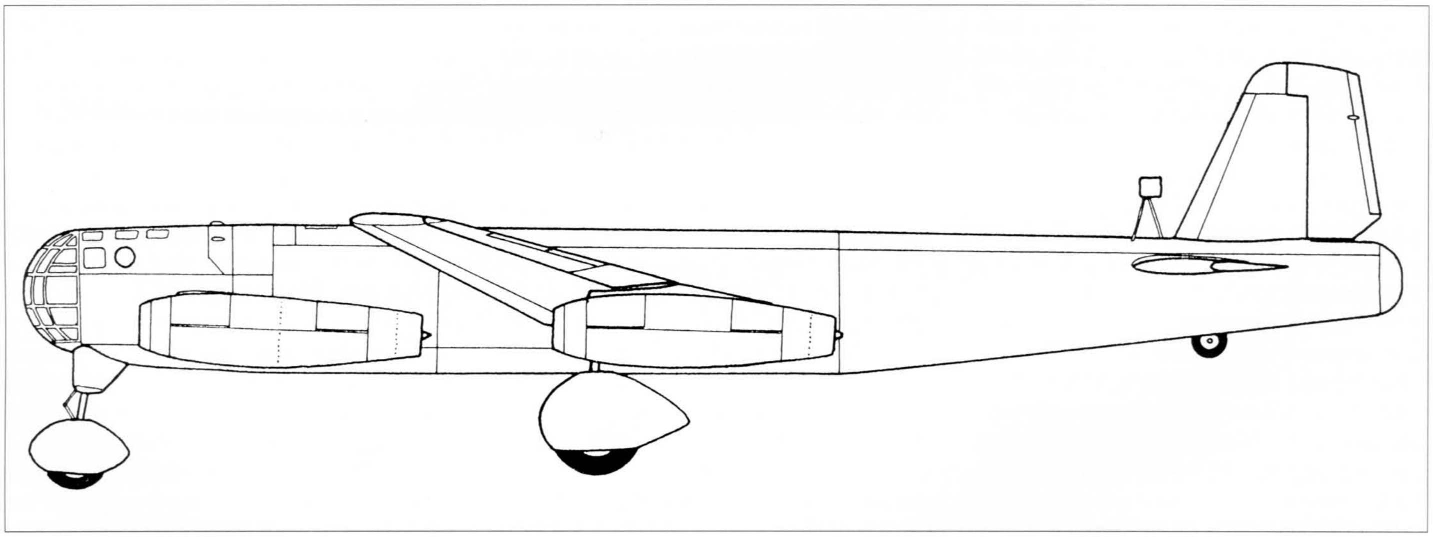
Jet aircraft development in Europe and the USA had begun as early as the mid-1930s. British and German scientists and aircraft designers were ahead of the field in this respect. The world's first turbojet-powered aircraft, the Heinkel He 178 proof-of-concept aircraft, took to the air on 24th August 1939. The He 178 was intended for verifying the Heinkel HeS 1 centrifugal-flow turbojet. Its cantilever high-wing layout with a retractable tailwheel undercarriage was markedly different from that of the first British jet, the Gloster G.40; this low-wing monoplane with a tricycle landing gear first flew in May 1942. The USA joined the 'jet club' on 1st October 1942 when the Bell XP-59A Airacomet twinjet fighter made its maiden flight.

Soon enough jet engines found their way to production aircraft, both fighters and bombers. The first series-produced jet bomber was the Arado Ar 234 Blitz (Lightning) strike aircraft. The Ar 234 V1 prototype, which first flew on 15th June 1943, and the subsequent seven prototypes used a jettisonable take-off dolly, landing on three retractable skids under the fuselage and the engine nacelles; later prototypes and the production version, however, featured a conventional tricycle undercarriage retracting into the fuselage. A total of 210 Ar 234B-1 reconnaissance aircraft and Ar 234B-2 bombers had been built by the end of the Second World War. The Ar 234B-2 was powered by two Junkers Jumo 004B-4 axial-flow turbojets rated at 800 kgp (1,760 lbst); the top speed was 750 km/h (465 mph) at 6,000 m (19,685 ft) and the service ceiling 11,700 m (38,385 ft). The bomb load was 1,500 kg (3,310 lb) at an all-up weight of 8,400 kg (18,520 lb).

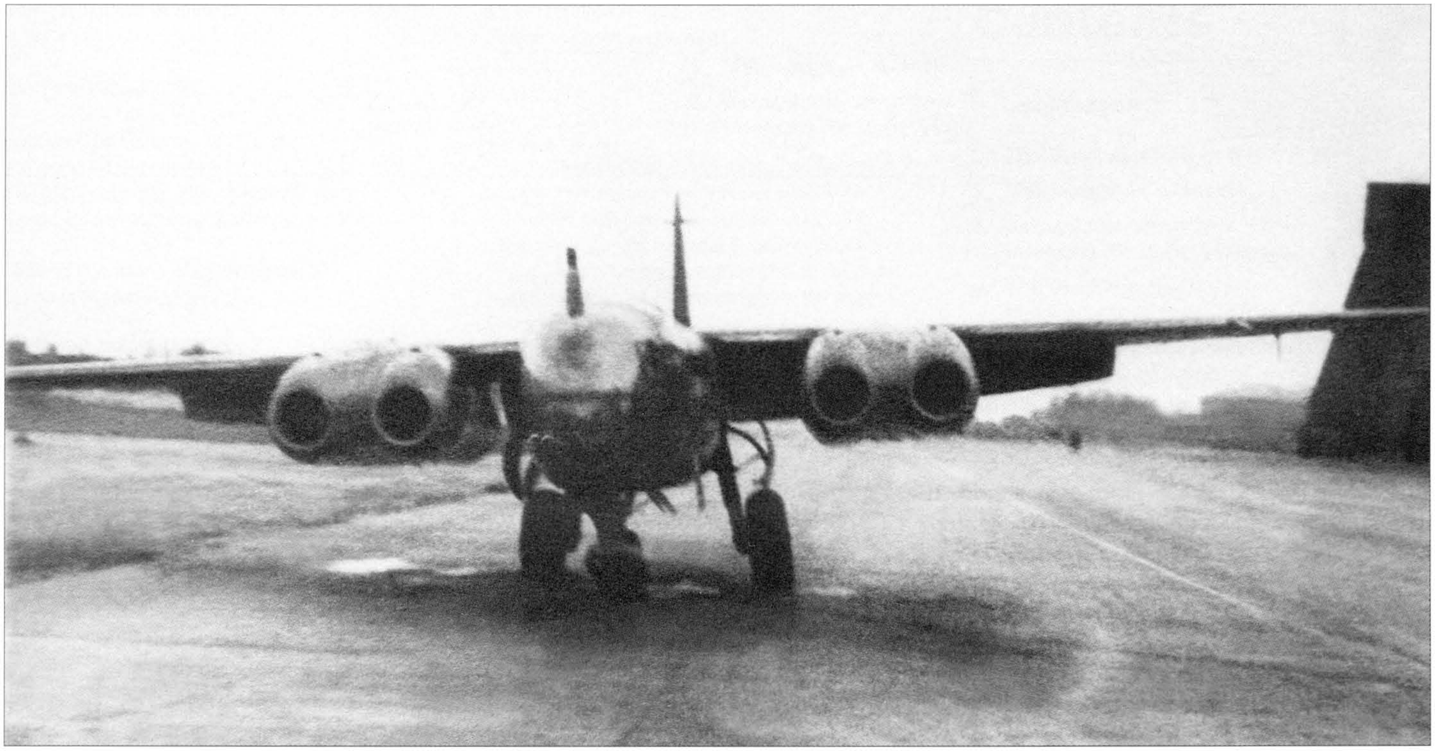
Another German bomber, the unorthodox Junkers Ju 287 V1 (V = *Versuchsmuster* – test article) with forward-swept wings which took to the air in August 1944, was the world's first medium jet bomber powered by four turbojets – a different version of the Jumo 004B rated at 900 kgp (1,980 lbst). The aircraft had a 20,000-kg (44,090-lb) all-up weight and attained a top speed of 645 km/h (400 mph). The first production example (the Ju 287 V3), which was still incomplete when the hostilities ended, was to have a top speed of 860 km/h (534 mph), a range of 6,650 km (4,130 miles) and a 3,000-kg (6,610-lb) bomb load.

The Soviet Union, too, undertook research in this field during the war. Nearly all of the Soviet aircraft design bureaux had jet aircraft in the making. The famous 'Fighter King' Nikolay N. Polikarpov led the way, followed by other Soviet aircraft designers. Starting in 1939, the design bureaux headed by Polikarpov (OKB-51), Aleksandr S. Yakovlev (OKB-115), Semyon A. Lavochkin (OKB-301), Artyom I. Mikoyan (OKB-155), Pavel O. Sukhoi and Semyon M. Alekseyev (OKB-21) developed, built and tested fighters featuring mixed powerplants which made use of ramjet boosters, liquid-fuel rocket boosters or a 'quasi-turbojet' with a shaft-driven compressor powered by the main piston engine. (OKB = ***op****ytno-kon****strook****torskoye byu****ro*** – experimental design bureau; the numbers are codes allocated for security reasons. Sukhoi's design bureau was then known as OKB-134; it was liquidated in 1949 but subsequently re-emerged as OKB-51, inheriting the number of the defunct Polikarpov OKB.)

Early Soviet research on true turbojets goes back to the late 1930s as well. Thus, a design team headed by Arkhip M. Lyul'ka, the Soviet pioneer of jet engine design, proposed a turbojet with a take-off thrust of 400 kgp (880 lbst) in 1938. After the project had been approved, the People's Commissariat (ie, Ministry) of Aircraft Industry (NKAP – *Na****rod****nyy komissari****aht*** *aviatsi****on****noy pro****mysh****lennosti*) allocated funds for manufacturing a prototype engine and transferred the designer to the Leningrad-based Machinery Plant named after Sergey M. Kirov where the SKB-1 special design bureau (*spetsi****ahl'****noye kon****strook****torskoye byu****ro***) had been set up for jet engine development. Soon SKB-1 developed the project of the RD-1 turbojet (*reak****tiv****nyy* ***dvig****atel'* – jet engine) with a take-off rating of 500 kgp (1,100 lbst) and a multi-stage axial compressor. A more powerful engine rated at 600 kgp (1,320 lbst) was on the drawing boards, but the outbreak of the Great Patriotic War on 22nd June 1941 foiled these plans.



This side view of the Junkers Ju 287 V1 development aircraft (RS+RA), the world's first four-jet bomber, shows well the unconventional engine arrangement. Note the fixed landing gear, the tail bumper wheel and the podded ciné camera on top the aft fuselage to record the airflow over the forward-swept wings.



The Arado Ar 234C was the second German four-jet bomber. This Ar 234C-1 is seen at a German airfield after being captured by Soviet troops. The starboard mainwheel tyre is flat, hence the strange lop-sided attitude.

After the war the development of jet aircraft and jet engines became a high-priority task for the Soviet aircraft industry. A lot of money and talent was assigned to this monstrous effort; still, jet aircraft development took time. Hence to speed up the process and give the Soviet Air Force the much-needed jet hardware the Soviet government decided to make use of German experience in this field.

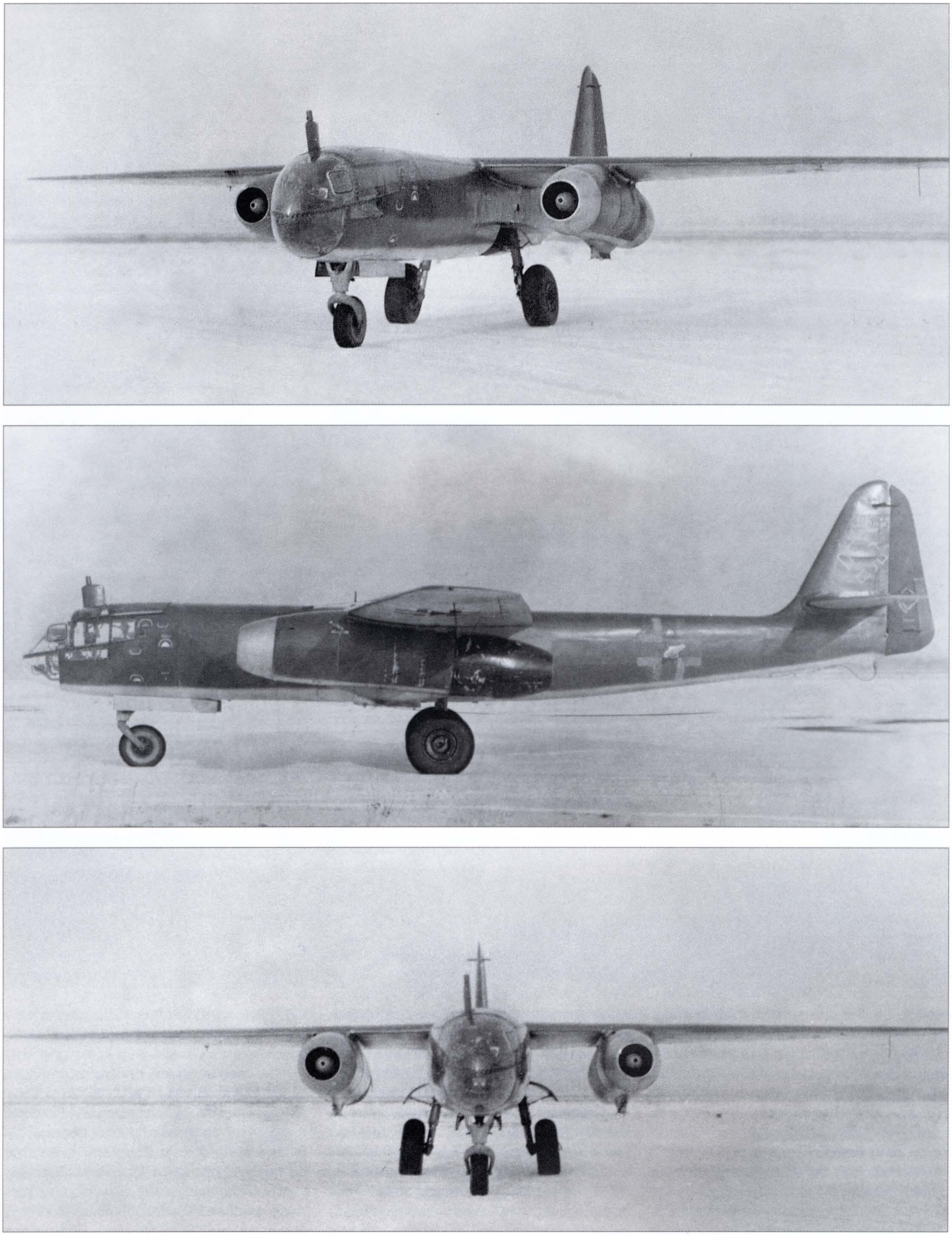
Like the other Allied nations, in 1945 the Soviet Union had come into possession of a lot of materials on jet aircraft, including both actual hardware and project materials. The captured jet- and rocket-powered aircraft underwent extensive testing at the Red Banner State Research Institute of the Air Force (GK NII VVS – *Gosoo**dar**stvennyy krasnozna**myon**nyy na**ooch**no-is**sled**ovatel'skiy insti**toot** Vo**yen**no-voz**doosh**nykh seel*); they were carefully studied at the Flight Research Institute named after Mikhail M. Gromov (LII – ***Lyot**no-is**sled**ovatel'skiy insti**toot***) and the Central Aero- & Hydrodynamics Institute named after Nikolay Ye. Zhukovskiy (TsAGI – *Tsen**trahl'**nyy **a**ero- i **ghid**rodina**mich**eskiy insti**toot***) which wrote detailed reports and disseminated them to the various enterprises in the NKAP system, including the aircraft and aero engine design bureaux. The 900-kgp Junkers Jumo 004B and 800-kgp BMW 003A turbojets, which had achieved production status, were of special interest; it was decided to launch production of these engines in the Soviet Union as a matter of urgency.

On 28th April 1945 NKAP issued an order requiring Chief Designer Vladimir Ya. Klimov, whose engine design bureau had been evacuated to aero engine factory No.26 in Ufa, to make manufacturing drawings of the Jumo 004B and launch production of the engine at the same plant as the RD-10. Another NKAP order of 13th June 1945 gave similar instructions to D. V. Kolosov, Director of the Kazan' aero engine factory No.16, with respect to the BMW 003A which was to be reverse-engineered as the RD-20. Both engines entered production in 1946.

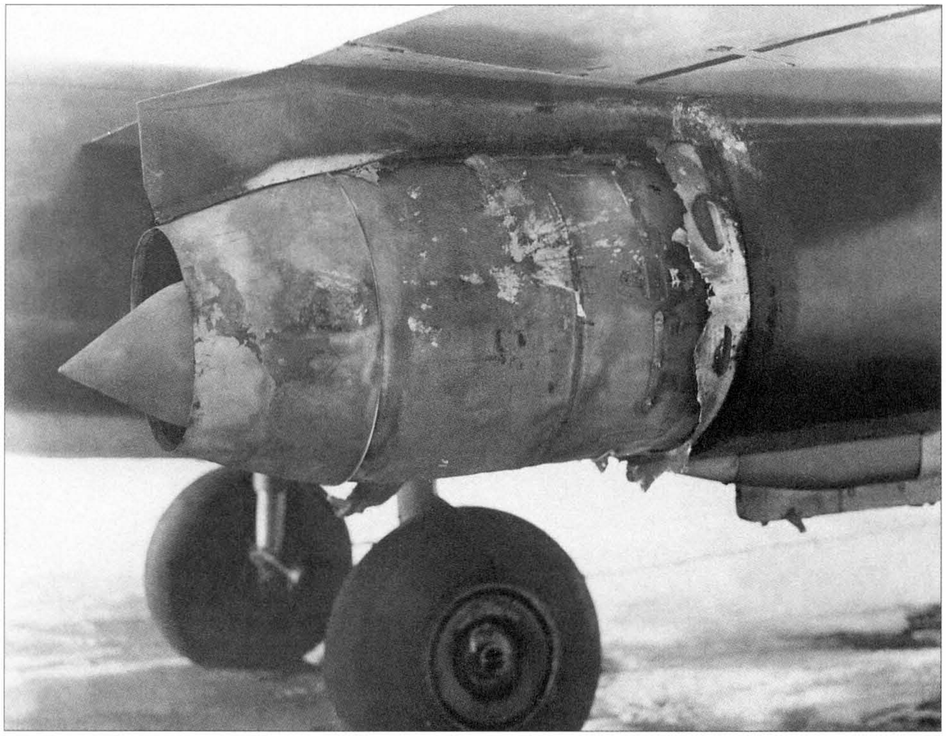
Despite the high priority attached to the copying of German engines in the immediate post-war years, it was clear that progress in the field of Soviet jet engine development could only be attained by furthering indigenous designs and technologies. In 1945 the Lyul'ka S-18 experimental axial-flow turbojet beat the Jumo 004 outright in a series of comparative tests; the Soviet engine was not only more powerful, with a take-off rating of 1,250 kgp (2,755 lbst), but also lighter and more fuel-efficient. For the purpose of creating a flight-cleared version of this engine (designated TR-1) and manufacturing a small production batch NKAP established the OKB-165 design bureau in 1946, with Arkhip M. Lyul'ka as Chief Designer.

Purchasing state-of-the-art jet engines in the West (again for the purpose of saving time) was again a high-priority task but the chances of doing it were pretty slim. After the Second World War the former allies in the anti-Hitler coalition quickly moved from a reluctant 'marriage' to an all-out 'divorce' (ie, the Cold War). When the People's Commissar of Aircraft Industry Mikhail V. Khrunichev and aircraft designer Aleksandr S. Yakovlev stated their intention to purchase the Rolls-Royce Nene I and Derwent V engines in Great Britain to Iosif V. Stalin, the Soviet leader retorted with typical candour, 'Pooh! Who's stupid enough to sell his secrets?' Yet the year was 1946 and the relationship between the Soviet Union and the West had not yet soured completely. The Soviet Union did find partners – the British Labour government sanctioned the sale of the said engines by Rolls-Royce. The aircraft designer Artyom I. Mikoyan, engine designer Vladimir Ya. Klimov and metal specialist S. Kishkin were sent to the UK to negotiate the purchase of the engines. 'Mission Impossible' ended in success: the USSR came into possession of 30 brand-new Derwent Vs and 25 Nene Is and Nene IIs. The engines were immediately subjected to careful study at the Central Aero Engine Institute (TsIAM – *Tsen**trahl'**nyy insti**toot** aviatsi**on**novo mo**tor**ostro**yen**iya*) and tested on a Tupolev Tu-2LL engine testbed. Concurrently preparations were launched for licence production of the Derwent V and Nene I as the RD-500 and RD-45 respectively, the figures being the numbers of the NKAP engine factories where they were produced. The process was supervised by Klimov who subsequently was responsible for all further work on improving and developing these engines.

Enlisting the help of German aviation industry specialists was another task of top importance. It was quickly established that most of the captured German aircraft industry



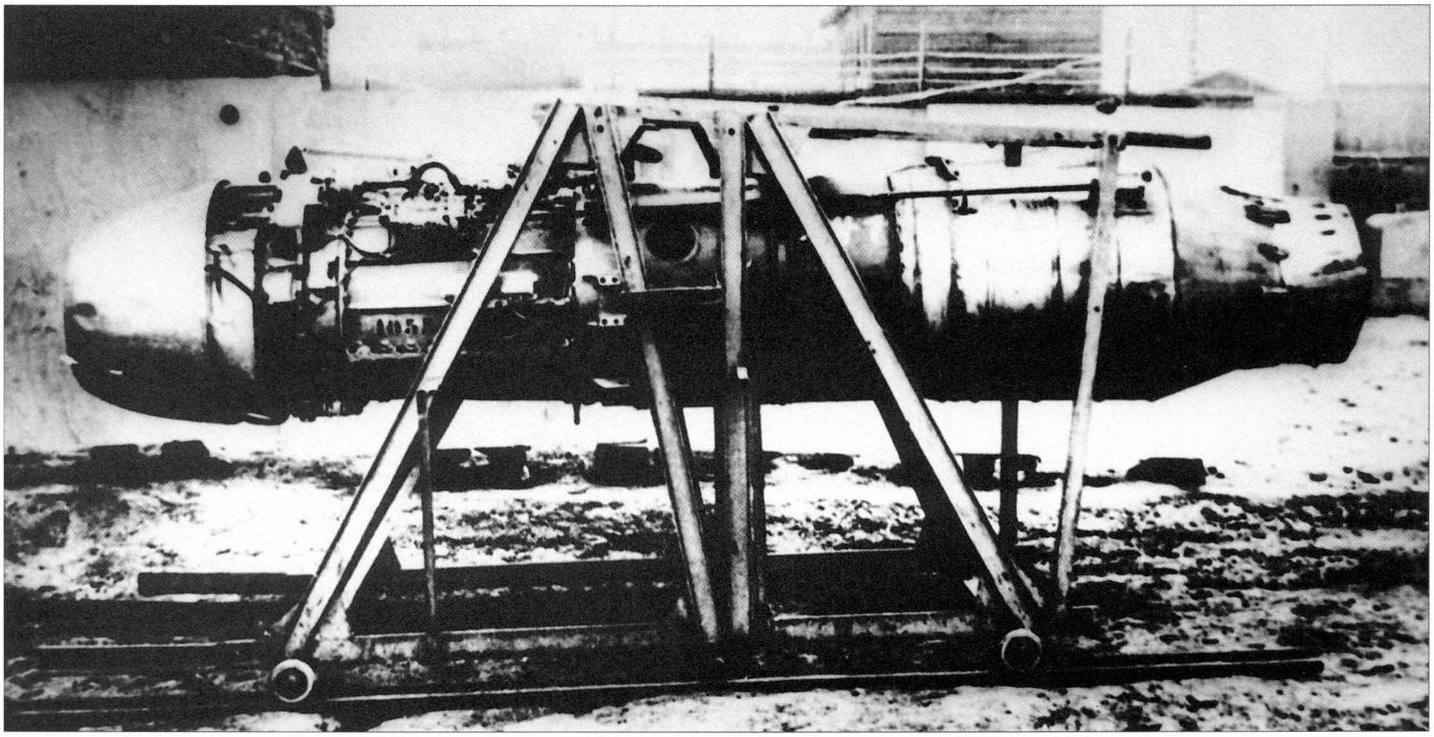
Three views of an uncoded Arado Ar 234B-2 (W.Nr. 140355) undergoing tests at Püttnitz, Germany, in late 1945. Note the extremely narrow landing gear track and the ETC 530 shackles for additional bombs – or solid-fuel rocket boosters – under the engine nacelles. The object above the cockpit is a rear-view periscope.



Left: The rear end of the starboard engine nacelle on Ar 234B-2 W.Nr. 140355 after an engine fire. The scorched rear portion of the cowling has been removed, exposing the engine casing and the translating nozzle centrebody of the Jumo 004B turbojet.

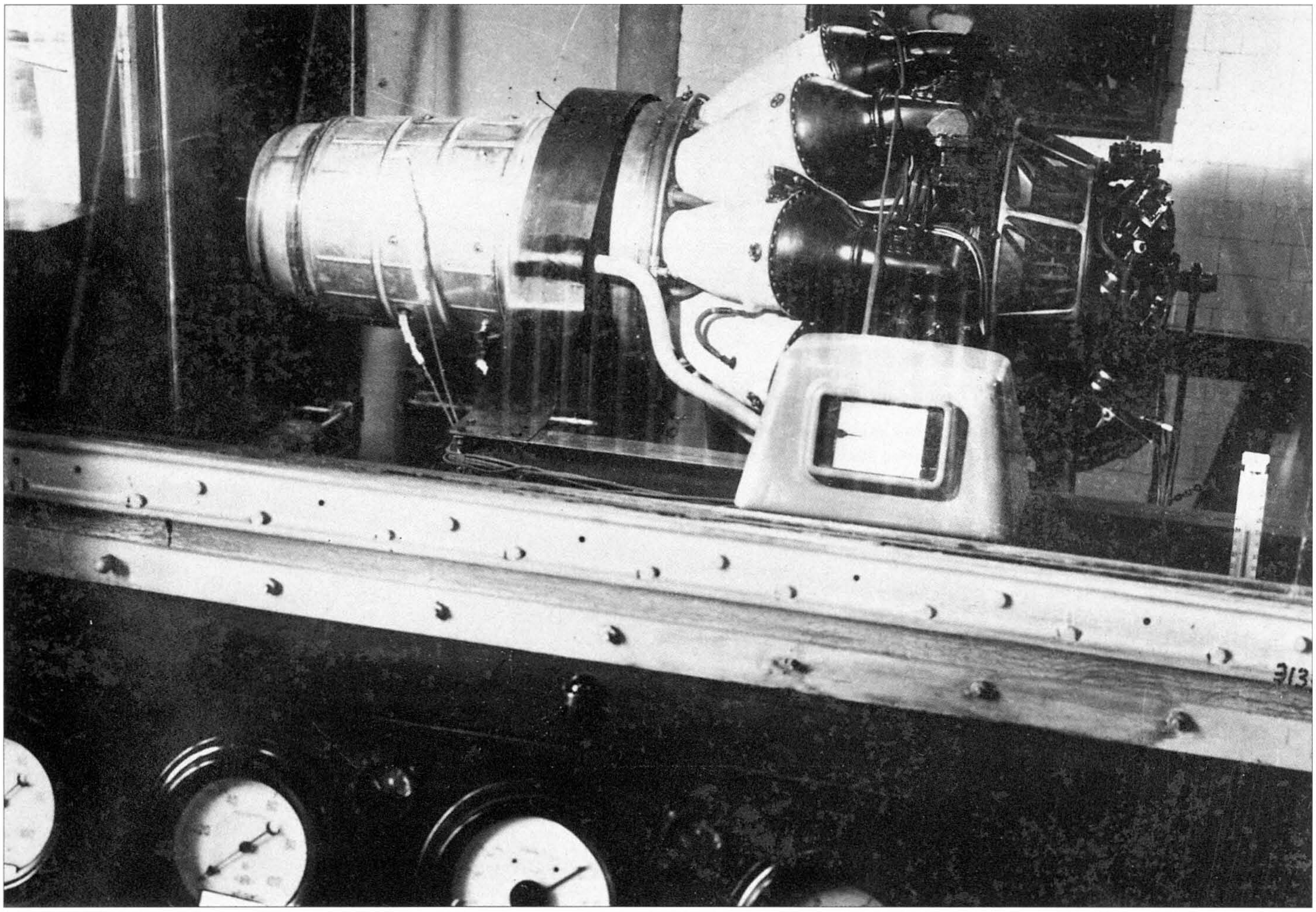
Below: Soviet engineers immediately set about refining the RD-10 (the reverse-engineered version of the Jumo 004). The propulsion department of the Lavochkin design bureau (OKB-301) headed by Ivan A. Merkoolov developed an afterburner for the RD-10. The resulting RD-10 F had a take-off thrust of 1,240 kgp (2,730 lbst) versus 800 kgp (1,760 lbst).

Opposite page: An imported Rolls-Royce Nene I turbojet undergoing bench tests at the Central Aero Engine Research Institute (TsIAM).



enterprises were well-equipped with test and research installations and possessed highly qualified personnel capable of tackling new design tasks. This prompted NKAP's Special Directorate (the counter-intelligence office) to propose using German specialists not only for repairing and testing captured German hardware in the USSR but also for creating new aircraft types, continuing the work on the projects which had been interrupted by the Allies' victory. Quite possibly the idea of working for the victors originated to a considerable degree from the German engineers, who would rather work for the Soviet occupation authorities than join the huge army of the unemployed. Hence new OKBs were established in the Soviet occupation zone; the largest of these with about 500 employees was based at the former Junkers AG factory in Dessau. The design bureau of BMW AG's former jet engine factory employed 90 engineers and designers. To give the idea legal status, the NKAP top brass addressed Stalin in late 1945, requesting approval for assignments to develop new jet aircraft, jet engines and various equipment items in Germany with the help of local specialists. This was to take place at OKBs located in Dessau, Halle, Strasfurt and Berlin.

The lion's share of the government assignments was given to OKB-1 in Dessau. Among other things, this team was to develop the Junkers Ju 131 and Ju 132 bombers (in paperwork they were commonly referred to as the EF-131 and EF-132, the prefix standing for *Entwicklungsflugzeug* – development aircraft), the Jumo 004 and Jumo 012 turbojets and the Jumo 224 diesel engine. To this end two large departments responsible for aircraft



and engine design were organised at OKB-1. The aircraft department had 433 employees, including 276 designers and 157 researchers working in research laboratories; the engine department had 402 specialists. A total of 2,992 persons, including 20 NKAP representatives, worked at the Dessau factory in May 1946. The aircraft department was headed by Brunolf W. Baade, with aerodynamicist Friedrich Franz Freitag (commonly known as Fritz Freitag) as his deputy; the department was supervised by P. N. Obroobov, an engineer seconded to the former Junkers AG from NKAP plant No.240 (the Ilyushin OKB) in 1946.

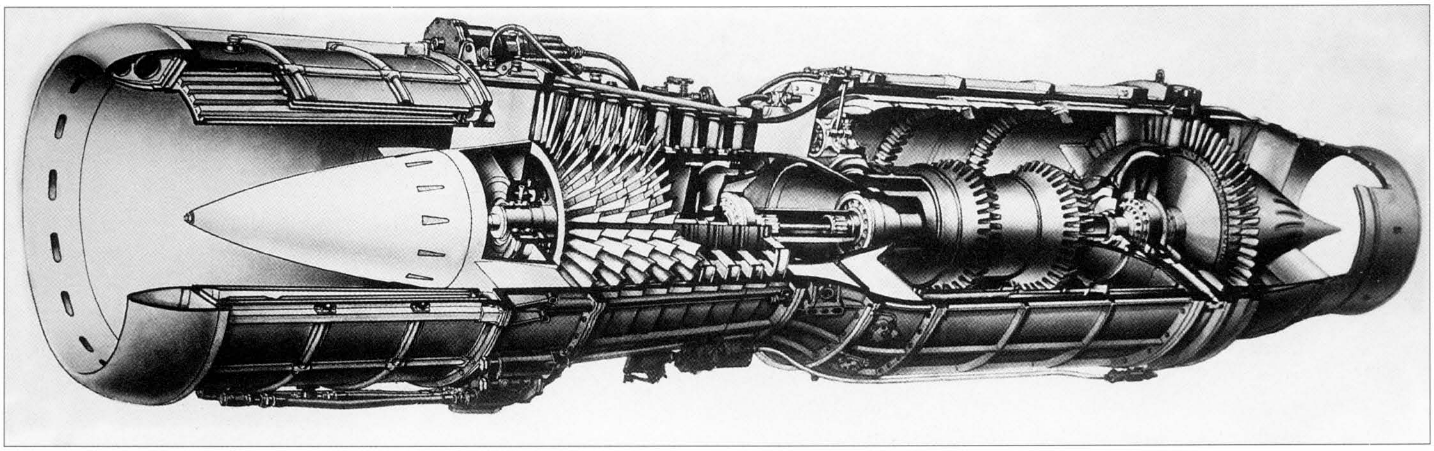
According to the plan for 1946 OKB-1 was to build four prototypes of the EF 131 and complete development of the heavier EF 132 (to be built in 1947). Furthermore, 30 Jumo 004F engines and 15 Jumo 012s were to be manufactured by the end of the year.

Of all Junkers aircraft the Soviet Union had laid hands on, the Ju 287 bomber was of the greatest interest. The four jet engines enabled it to reach speeds rendering it immune to attacks by piston-engined fighters. This bomber was the brainchild of Hans Wocke who utilised unconventional forward-swept wings in order to avoid the tip stall problem characteristic of ordinary swept wings. On the other hand, forward-swept wings could create aeroelasticity problems; yet Wocke believed these problems could be tackled by optimising the design (among other things, the engines were to be mounted ahead of the wings' torsional stiffness axis).

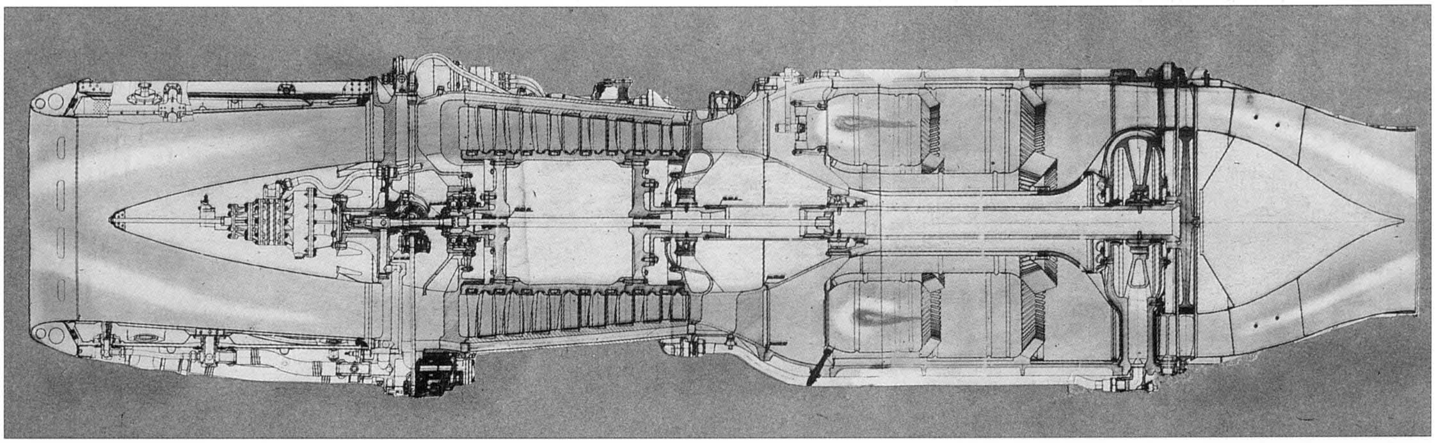
The first prototype (Ju 287 V1), which featured two engines under the wings and two more on the forward fuselage sides, had been damaged during a bombing raid against Junkers' Dessau facility. However, the company had begun construction of the second prototype powered by six turbojets mounted in clusters of three under the wings; the aircraft was to have an all-up weight of 21,200 kg (46,740 lb), a top speed of 800 km/h (496 mph) and a 4,000-kg (8,820-lb) bomb load. It was the incomplete Ju 287 V2 that served as the basis for a new experimental bomber which would be one of the Soviet Union's first jet strike aircraft.

Right from the start it was envisaged that the Ju 287 and the other combat aircraft built in Germany would pass their flight tests in the Soviet Union. For one thing, the close proximity of the British and US occupation zones made it impossible to keep the aircraft secret from the former Western allies; worse, there was a considerable risk that the German test pilots would attempt to flee to the British or US zone. Hence the German specialists, together with their families and worldly goods, were quickly transferred to a place securely within Soviet territory – an offer they could not refuse. Further work took place in the Soviet Union, culminating in the creation of the first 'Soviet' jet bombers described in this book.

To be perfectly honest, the 'imported' German specialists did their utmost to fulfil the task, even though the conditions they worked in left a lot to be desired. In June 1948 Brunolf Baade wrote to I. A. Serov, the then Vice-Minister for State Security: *'Our team, which has always enjoyed your attention and support, is now going through the hardest times…'* Concurrently his colleague Hans Rössing wrote to Council of Ministers' Chairman Vyacheslav M. Molotov and I. V. Stalin: *'We have been forced to move from Germany to a plant which for all practical purposes lies in ruins. For several months our specialists have been engaged in construction work, relocation of equipment etc. By the end of the year only part of the equipment required for aircraft manufacturing had been installed at the plant by the end of the year. Material and instrument supplies so far have been almost non-existent… […] I assure you that we are prepared to do our utmost, and the entire collective would be happy if you would provide us with the means and conditions enabling us*



Above and below: A cutaway drawing and a diagram of the Lyul'ka TR-1 – the first flight-cleared turbojet engine developed in the Soviet Union. Note the exceptionally long pointed intake centrebody housing the starter-generator and the 'waist' of the engine casing ahead of the combustion chamber.

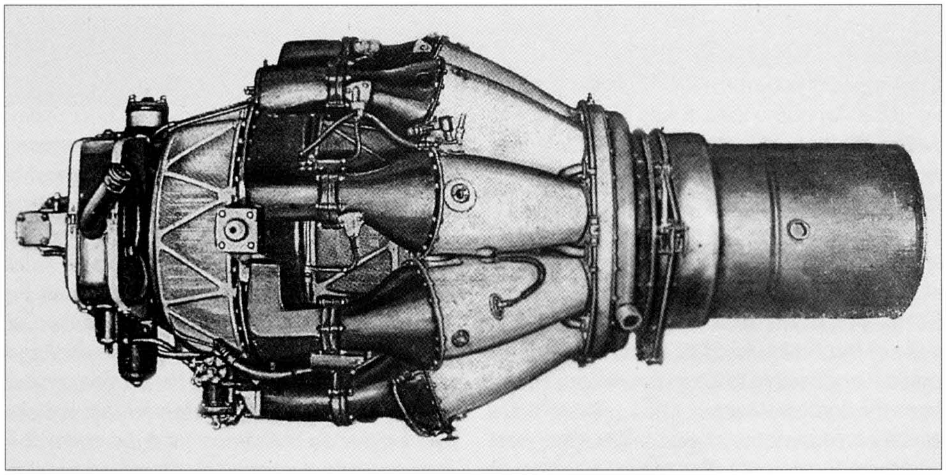


to work successfully. In that case you would have an experienced team which you could justly expect to achieve significant results...'

The cry for help was heard; the Soviet Ministry of Foreign Affairs and the Ministry of the Interior demanded that the Ministry of Aircraft Industry (MAP – *Mini***ster***stvo aviatsi***on***noy pro***mysh***lennosti*), as the former NKAP was known since early 1947, should sort out the situation. At Mikhail V. Khrunichev's orders MAP held a working session to deal with the issue which Baade and Rössing were invited to attend. In October 1948 the experienced aircraft designer Semyon M. Alekseyev was appointed Chief Designer of plant No.1 where the 'German' OKB-1 was based, and the tempo of the work increased appreciably.

As already mentioned, nearly all Soviet aircraft design bureaux were then working on jet aircraft projects. Besides OKB-1, jet bombers were under development in the design teams headed by Sergey V. Ilyushin (OKB-240), Pavel O. Sukhoi, Vladimir M. Myasishchev (OKB-482), to say nothing of OKB-156 led by Andrey N. Tupolev, the doyen of Soviet heavy aircraft design. The principal aircraft types which laid the foundations of the Soviet Union's jet bomber force are described herein.

It makes sense to explain why this author has chosen to deal with the aircraft described herein in this specific order. There is no real reason for that – the order could just as easily have been different, since the aircraft in question were developed concurrently, often in keeping with the same government directives and NKAP/MAP orders. As for the 'red-star Germans', which apparently should be dealt with first (but are not), the order was influenced by the wish to give the most comprehensive picture of early Soviet jet bomber design. Thus the '150' bomber prototype, which belongs with the German designs but was certainly not one of the earliest designs (it was tested in 1952), caused the 'German' chapter to be shifted towards the end of the book. Surely you will agree that it makes sense to keep the 'birds of a feather' together, just as it would be illogical to describe a 1950s design at the beginning of the book and then go back to the 1940s again. The reason why the '150' was included in the first place is the uniqueness of the materials relating to it which have recently been revealed and which the reader might be interested in. Hopefully the reader will forgive this quirk and enjoy the book.



The Klimov RD-500 – the licence-built version of the Rolls-Royce Derwent V turbojet.

Chapter 1

The First Ilyushin Jet

IL-22 tactical bomber prototype

In 1946 the Soviet Air Force started taking delivery of its first jet fighters (the Yakovlev Yak-15 and the Mikoyan/Gurevich MiG-9). The rapid re-equipment of fighter units both in the Soviet Union and abroad created the necessity to introduce jet propulsion on bombers as well.

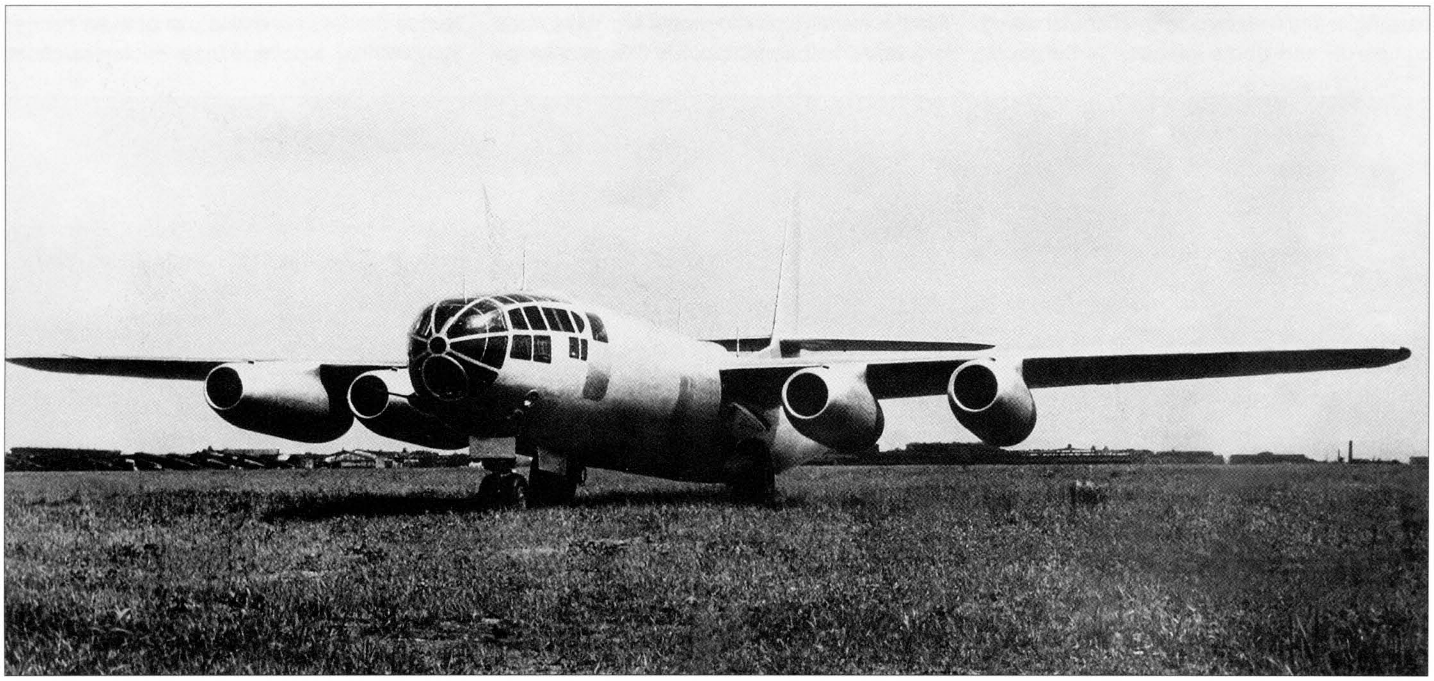
By the time jet aircraft development began in the Soviet Union, the Soviet aviation experts had obtained sufficient information about German work in this field; from Western trade magazines they could glean further information about heavy jet aircraft developed in the USA and Great Britain. Still, while this knowledge gave some food for thought, the USSR had no prior experience of designing, building and operating such aircraft.

The task of creating a fully capable short-range (tactical) jet bomber to replace the obsolete Second World War-vintage piston-engined types was quite a complicated one due to the early turbojet engines' high specific fuel consumption, which was nearly five times higher as compared to the piston engines of the time. This meant the fuel load had to be increased appreciably, which in turn necessitated a lot of research in order to determine the jet bomber's optimum dimensions and weights and select the optimum layout. The latter meant a layout which would give the aircraft an adequate warload at the specified speed and range while still affording enough room for installing potent defensive armament and mission avionics that would enable the bomber to accomplish the mission in the daytime and at night, in the face of the adversary's air defences and fighters.

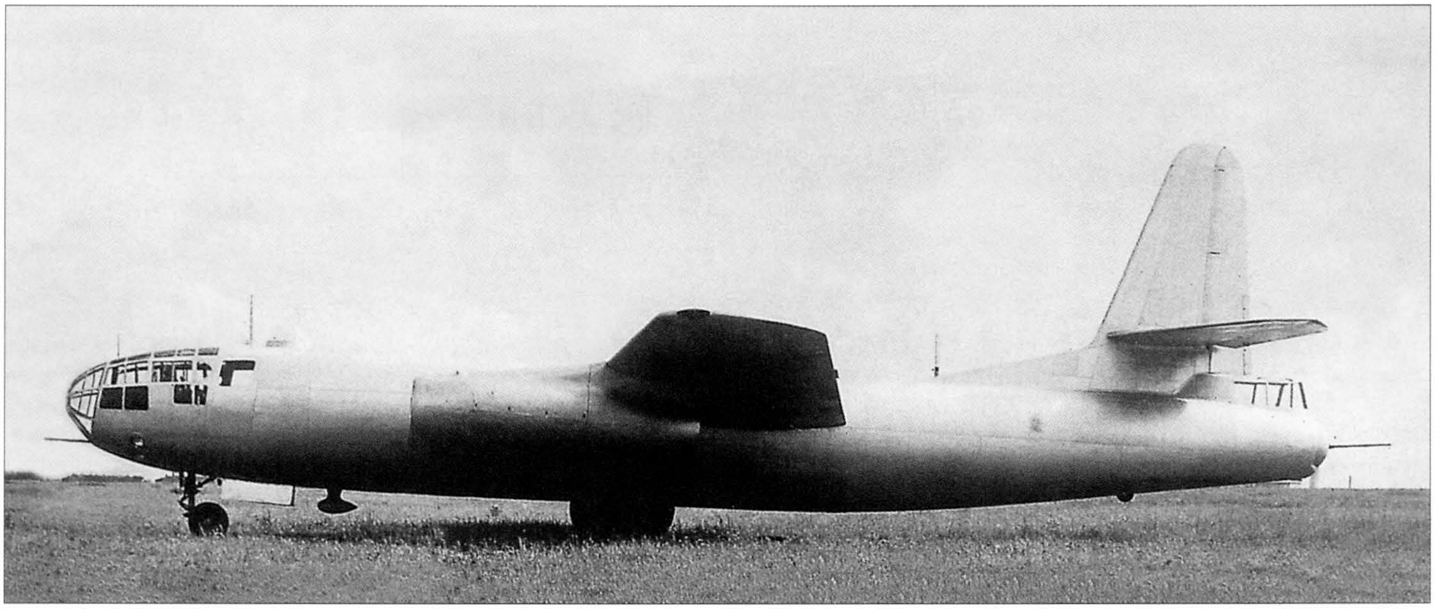
In order to find practical solutions to the problems associated with the development of heavy multi-engine jet aircraft the Soviet Council of Ministers issued a directive on 12th February 1946, ordering Sergey V. Ilyushin's OKB-240 to develop and submit for trials a bomber designated IL-22 and powered by four Lyul'ka TR-1 axial-flow turbojets. The aircraft was to have a 2,000-kg (4,410-lb) normal bomb load, a range of 1,250 km (776 miles), a cruising speed of 750 km/h (465 mph) and a normal take-off weight of 24 tons (52,910 lb). In maximum take-off weight (overload) configuration the range increased to 2,000 km (1,240 miles); the top speed was to be 800 km/h (496 mph) at 9,000 m (29,530 ft) and the maximum Mach number 0.75.

The design team of OKB-240, which was then quite small, set to work on the OKB's first jet aircraft. The preliminary design (PD) stage lasted from June to October 1946; work on the advanced development project (ADP) commenced in November. Despite the complexity of the project and the fact that Ilyushin had no prior experience with jets, the project was completed in an incredibly short time; the Soviet Union's first four-turbojet bomber incorporating a whole range of pioneering design features was ready for flight tests just a year after its inception.

The specified speeds made it possible to use a conventional aerodynamic layout with mid-set cantilever unswept wings and unswept tail surfaces; however, special measures were taken to minimise drag and offset the effects of the changes in the wing lift and longitudinal stability at high speeds. The IL-22 featured thin wings with an area loading of 310-350 kg/m^2 (63.5-71.75 lb/sq ft); the wings utilised symmetrical high-speed airfoils with a thickness/chord ratio of 12% and a maximum thickness at approximately 40% of the chord. The root sections featured the TsAGI 1A-10 airfoil generating relatively modest lift, while the outer wings used the TsAGI 1V-10 airfoil creating high lift. Apart from alleviating the harmful effects of the shock wave crisis, this



The sole prototype of the IL-22 bomber during manufacturer's flight tests. Note the optically flat circular glazing panel for the bombsight and the car-type flightdeck door (a second door was located symmetrically to starboard).

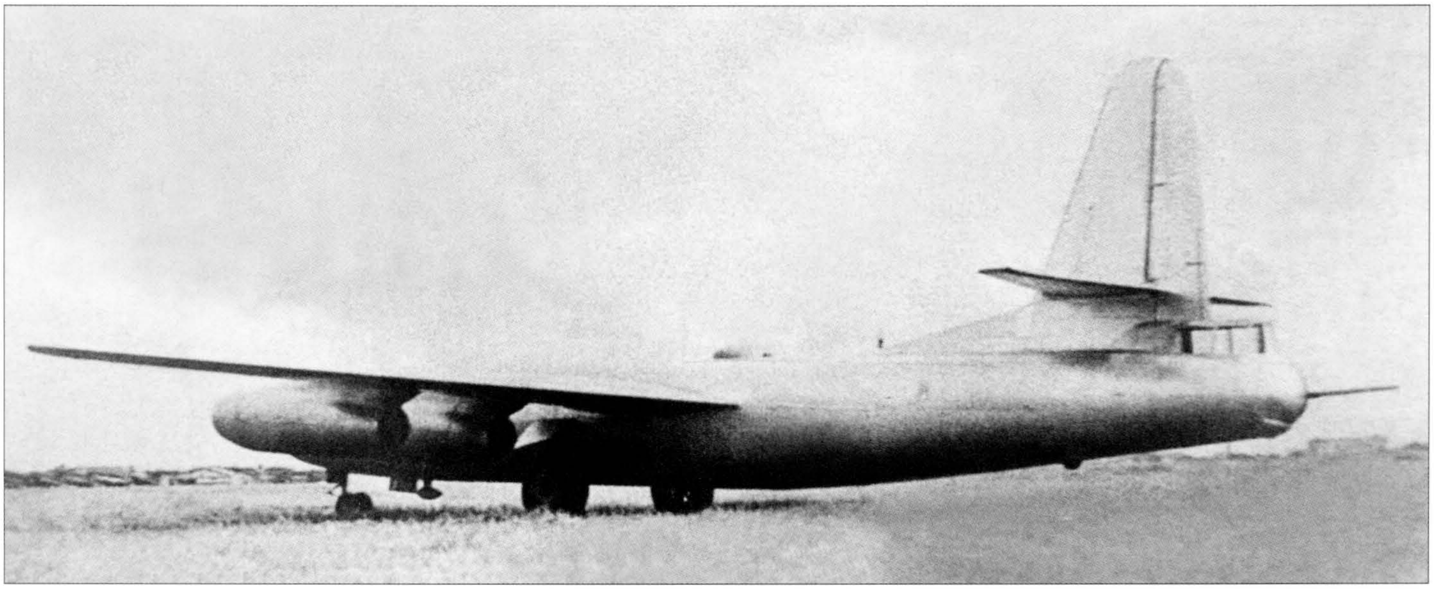


Above: This side view illustrates the IL-22's nose shape, the engines' position with respect to the wings and the extremely small ground clearance. The bomber assumed a nose-high attitude on the ground. Note the tail bumper and the direction finder loop aerial in a teardrop fairing aft of the nose gear.

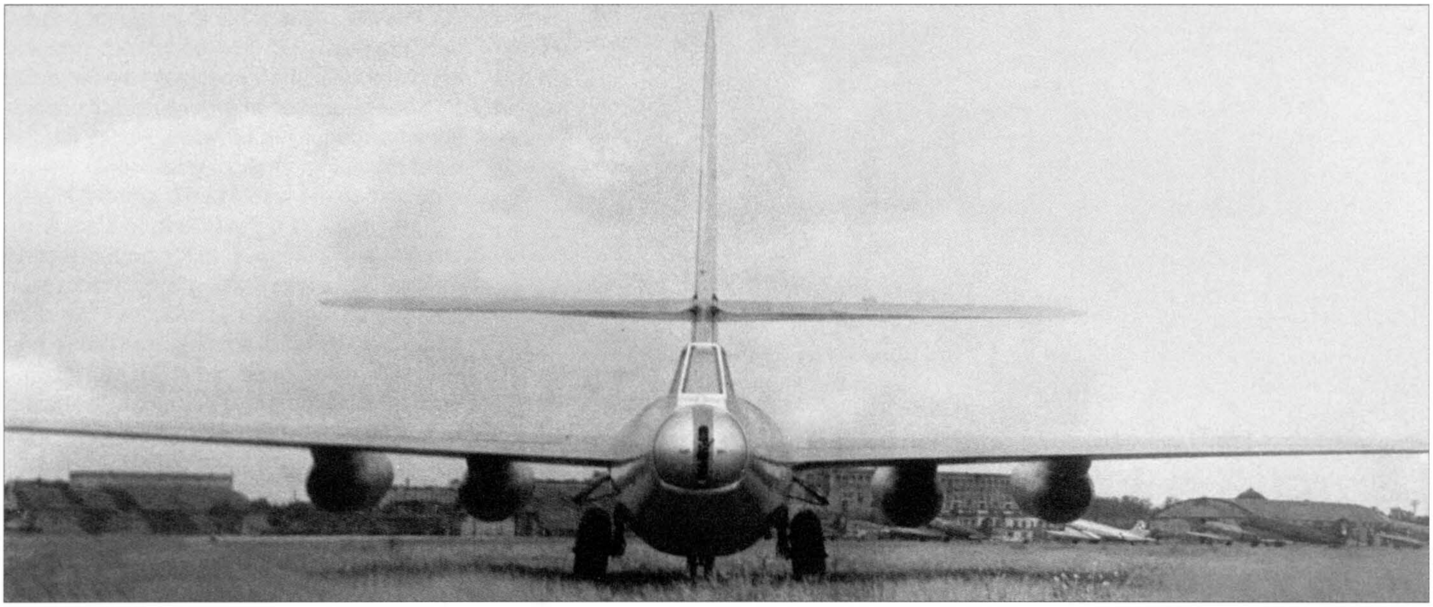
wing design improved lateral stability at high angles of attack, preventing the onset of tip stall.

Flight tests of early jet fighters revealed a phenomenon known in Russian as *val'**ozh**ka* – a tendency to drop a wing uncommandedly at high speeds and high altitudes. The cause of the trouble was traced to manufacturing inaccuracies (as it were, the port and starboard wings had slightly different airfoils generating different amounts of lift) which did not have any major effect on the aircraft's stability and handling at lower speeds. Recognising the problem, the Ilyushin OKB took great pains to ensure that the IL-22's wings were manufactured with a high degree of precision to preclude *val'ozhka* without resorting to methods causing a major increase in manufacturing complexity and labour intensity. At Sergey V. Ilyushin's initiative a new technology was devised for manufacturing the wings, tail unit and some components of the fuselage structure. This technology, which found its first practical application on the IL-22 prototype, involved using the aircraft's skin as a reference point – that is, to ensure the correct contours the internal structural members were attached to the skin panels which were fixed in the assembly jig, not vice versa (as had been customary until then). This was made possible by introducing manufacturing joints along the wings' and tail surfaces' chord lines, thereby splitting the ribs and spars in two. The same technique was used for manufacturing the forward and rear fuselage sections which were split vertically along the centreline, just like the average plastic model kit. At the price of a very small weight penalty this technology not only ensured that the correct airfoils and fuselage contours were observed but also simplified and accelerated the assembly process greatly, allowing the internal equipment to be installed in the halves of the major airframe subassemblies before these were joined together. This allowed several teams to work on a single subassembly at once and accounted in no small degree for the rapid completion of the prototype.

The layout of the IL-22's tail unit was chosen with the peculiarities of high-speed flight in mind. Its parameters, which were selected with a view to providing the required stability and control characteristics, ensured the onset of the shock wave crisis on the tail surfaces at higher mach numbers than on the wings. Hence the tail unit made use of even thinner symmetrical airfoils with a thickness/chord



A three-quarters rear view of the IL-22. The position of the dorsal barbette above the wing trailing edge is visible from this angle – not the best position, as it turned out. The tail gunner's station is located entirely aft of the tail surfaces. The aircraft was totally devoid of markings at first.



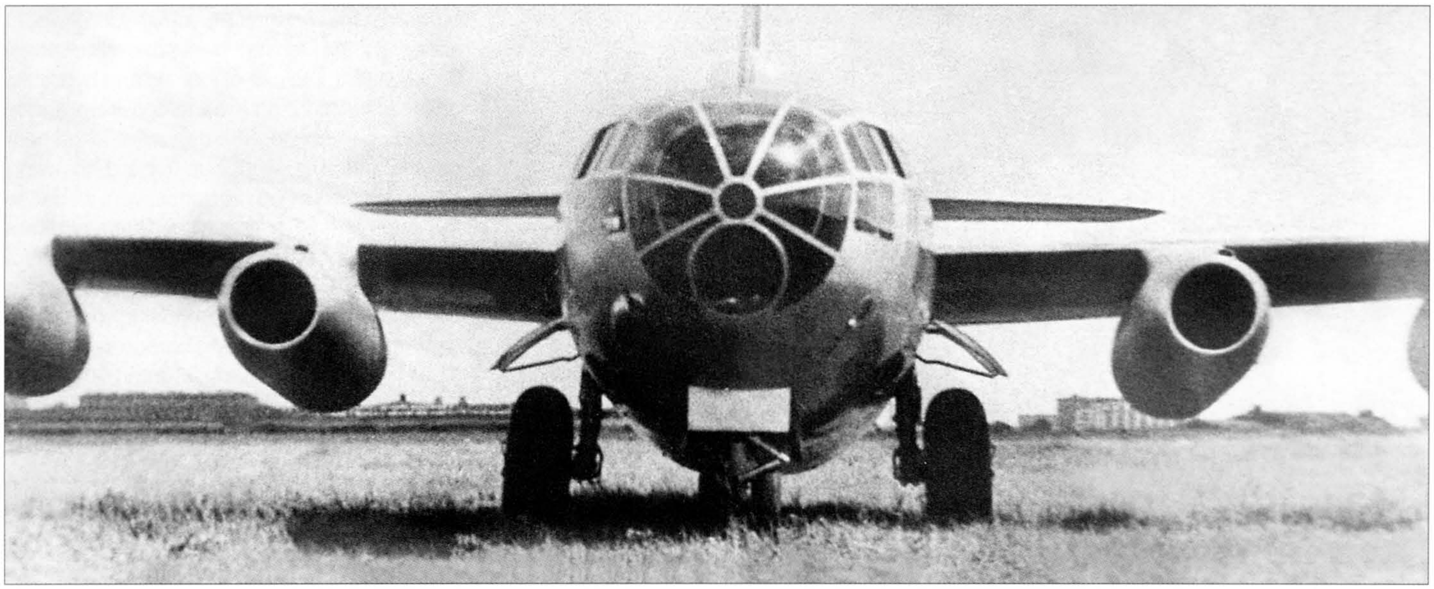
Above: A rear view of the IL-22 at Moscow-Khodynka, with Lisunov Li-2 (or Douglas C-47) transports in the background. Besides giving details of the IL-KU3 tail turret, this view illustrates the extremely narrow landing gear track – a weakness which the IL-22 shared with the Arado Ar 234.

ratio of 9-10%. The tail surfaces were arranged in cruciform fashion, the stabilisers being mounted on the fin and placed outside the wing upwash.

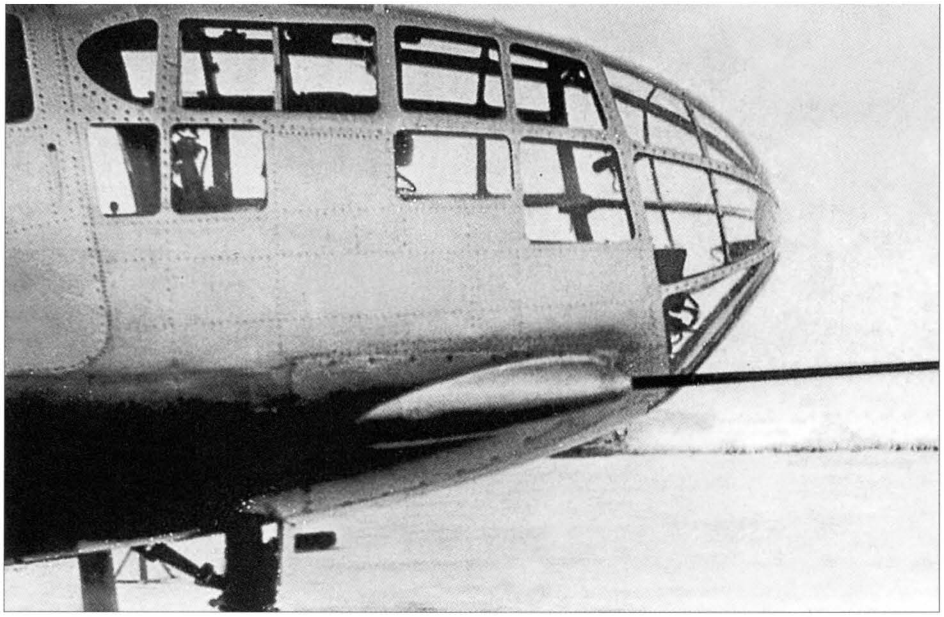
Choosing the optimum engine placement, fuselage parameters and landing gear design, all of which were interrelated, turned out to be no easier than designing the wings and tail unit. The few multi-engine jet aircraft existing at the time featured widely varying engine arrangements, including some really weird ones; most of them, however, had the engines either buried in the wings or located (singly or in clusters) in nacelles adhering directly to the wing undersurface. The cluster or package arrangement offered certain advantages over individual nacelles, reducing overall drag and interference drag somewhat; hence it was common in 1945-47, finding use on such aircraft as the Ar 234B and the Ju 287 V-3 prototype, as well as the North American B-45 Tornado, Convair B-46 and Martin B-48. The latter three bombers entered flight test in 1947 concurrently with the IL-22.

However, the cluster arrangement had serious shortcomings as well. The reliability of the day's jet engines left a lot to be desired, and the uncontained failure and/or fire of one engine in a cluster could put the neighbouring engines out of action, too. Operational experience proved that this was often the case.

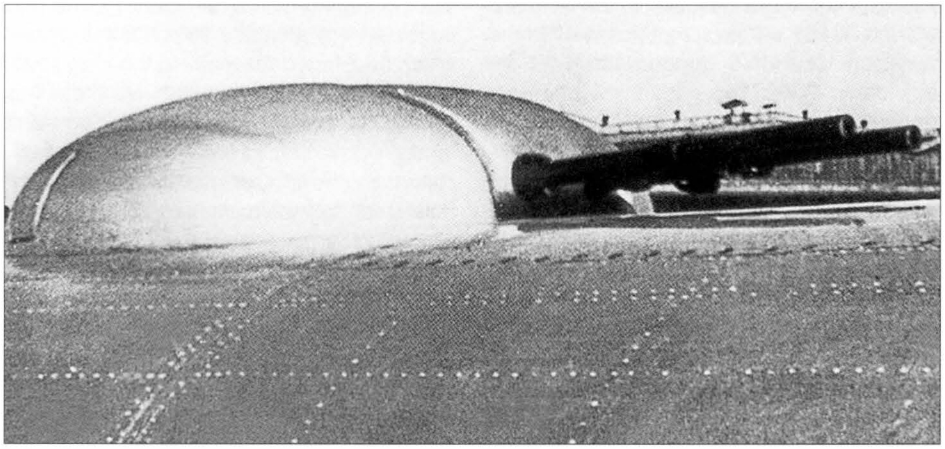
After analysing the merits and weaknesses of several alternative arrangements, including paired nacelles similar to those of the Ar 234B and B-45, the Ilyushin OKB developed an unusual layout with four widely spaced individual nacelles carried ahead of the wing leading edge on short horizontal pylons. The engines were attached solely to the pylons which transferred the loads to the wing structure, doubling as anti-flutter weights. This installation ahead of the wing leading edge turned out to be more efficient aerodynamically than the cluster arrangement. Also, it facilitated engine maintenance/change and allowed other engine types to be installed in case of need without requiring major changes to the wing structure – no small thing for an experimental aircraft, as the IL-22 was also effectively a testbed for the TR-1 turbojets. The podded underwing installation of jet engines on pylons later won universal recognition and was widely used on commercial and military aircraft developed both in the Soviet Union (and subsequently the CIS) and abroad.



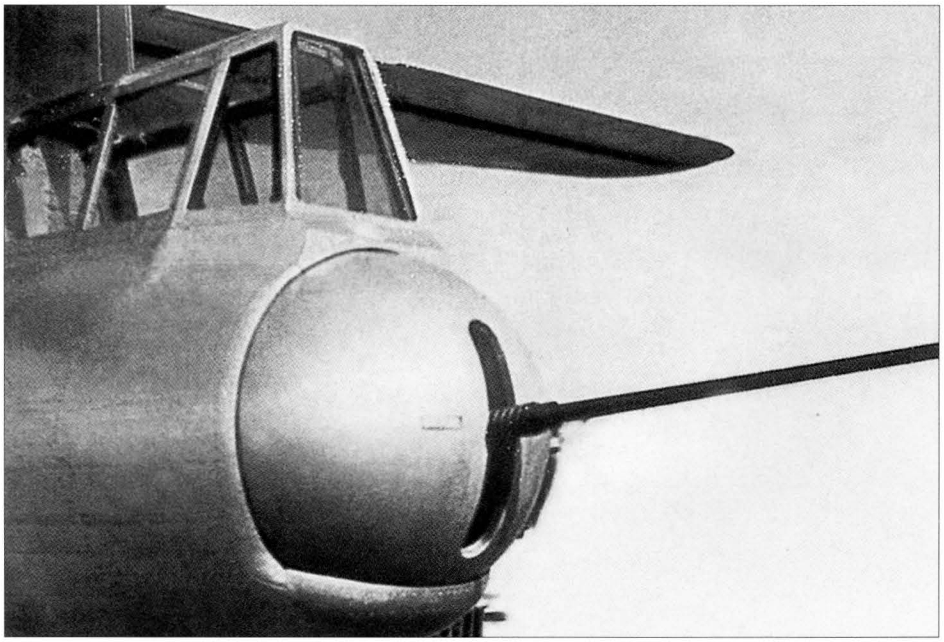
The IL-22's oval fuselage cross-section is evident in this view. Unusually, the torque link of the nose gear unit is mounted laterally instead of at the front, a measure designed to save space and avoid disrupting the fuselage contours with additional fairings.



Above: Close-up of the IL-22's extensively glazed forward fuselage with a forward-firing NS-23 cannon on the starboard side.



Above: The remote-controlled dorsal barbette mounting twin B-20E cannons. Note the heat-resistant steel plate riveted on aft of the cannon barrels to protect the skin from the blast.



The tail gunner's station and the IL-KU3 tail turret mounting another NS-23 cannon.

The TR-1 was a rather compact engine, and the neat nacelles could not possibly accommodate the large mainwheels which had been selected in order to enable operations from unpaved runways. Hence the forward-retracting main gear units were mounted on the fuselage. To widen the landing gear track in order to ensure acceptable stability and manoeuvrability on the ground the fuselage received an elliptical cross-section with the larger axis horizontal. The main gear fulcrums featured skewed axles to provide the widest possible track; due to the skewed axles the single wheels turned during retraction to stow in V fashion, side by side, ahead of the bomb bay which accommodated up to 3 tons (6,610 lb) of bombs. The twin-wheel nose gear unit retracted aft.

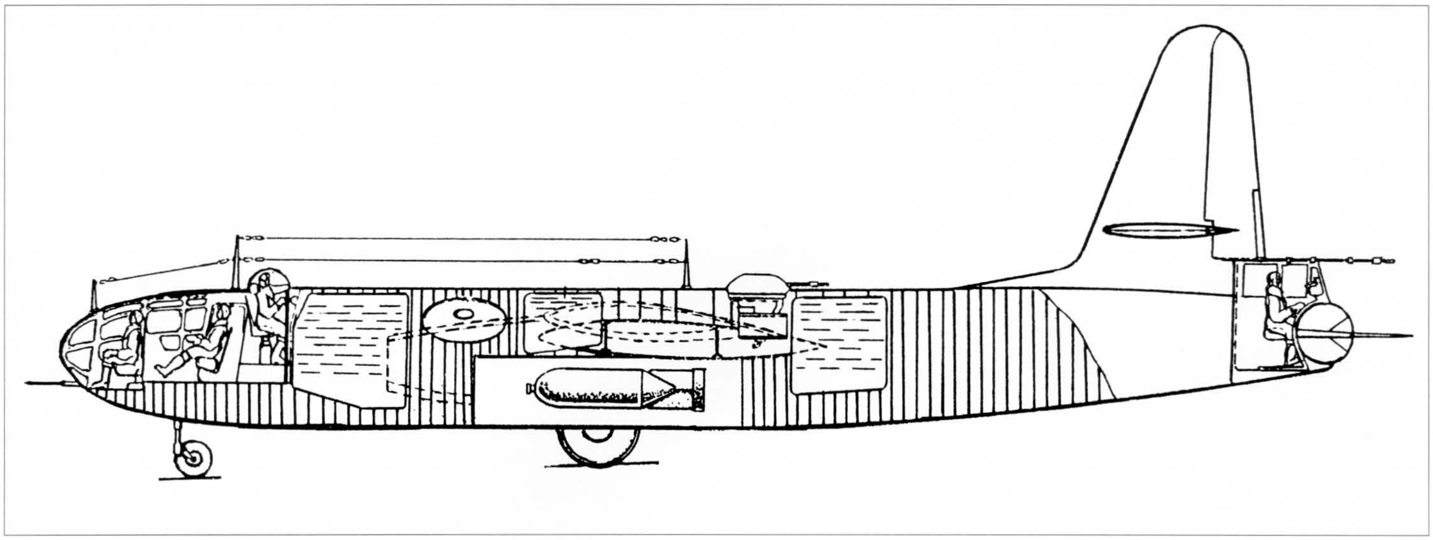
The chosen fuselage cross-section facilitated the accommodation of other items, too. Thus the wide fuselage provided ample room for the crew of five. The two pilots sat side by side, with the navigator/bomb-aimer ahead of them and the radio operator/dorsal gunner aft; the tail gunner had a separate compartment aft of the tail unit all to himself. The fuselage housed three bag-type fuel tanks holding a total of 9,300 kg (20,500 lb) – a huge fuel load as compared to a piston-engined bomber having similar range.

To minimise drag the designers chose not to use a stepped windscreen. The extensively glazed fuselage nose had a bullet shape reminiscent of the Boeing B-29 or the Arado Ar 234. The clean contours of the fuselage were broken only by a small observation/sighting blister and the dorsal cannon barbette further aft. The airflow speed and air pressure along the length of such a fuselage changed to a much lesser extent than in the case of, say, chordwise flow over the wings.

Speaking of armament, the IL-22's much higher speed as compared to piston-engined bombers meant that muscular force would not be enough to work the cannon barbettes, necessitating the use of electric and hydraulic drives. The IL-22 also benefited from a new approach to placing the defensive armament on the airframe with due regard to using remote controls (the barbettes were slaved to the gunsights). To check the efficacy of the powered barbettes and their remote control systems the aircraft was provided with a defensive armament comprising one fixed cannon and three cannon barbettes.

A single forward-firing 23-mm (.90 calibre) Nudel'man/Suranov NS-23 cannon with 150 rounds was installed on the starboard side of the forward fuselage. It was to be fired by the aircraft's captain who would use a primitive ring-type sight for aiming it.

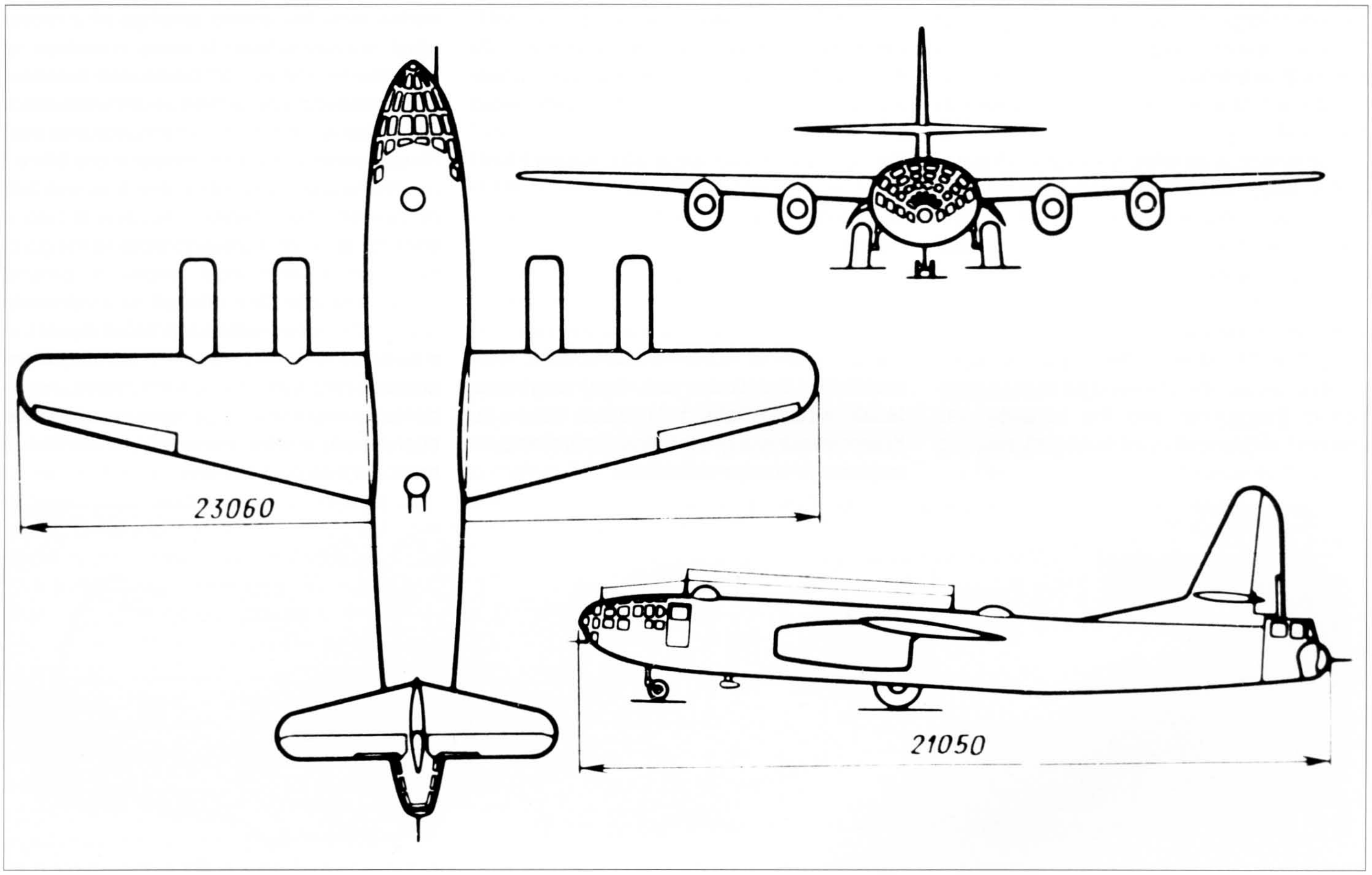
The dorsal barbette mounted two 20-mm (.78 calibre) Berezin B-20E cannons with 400 rpg; it provided almost 360° coverage of the



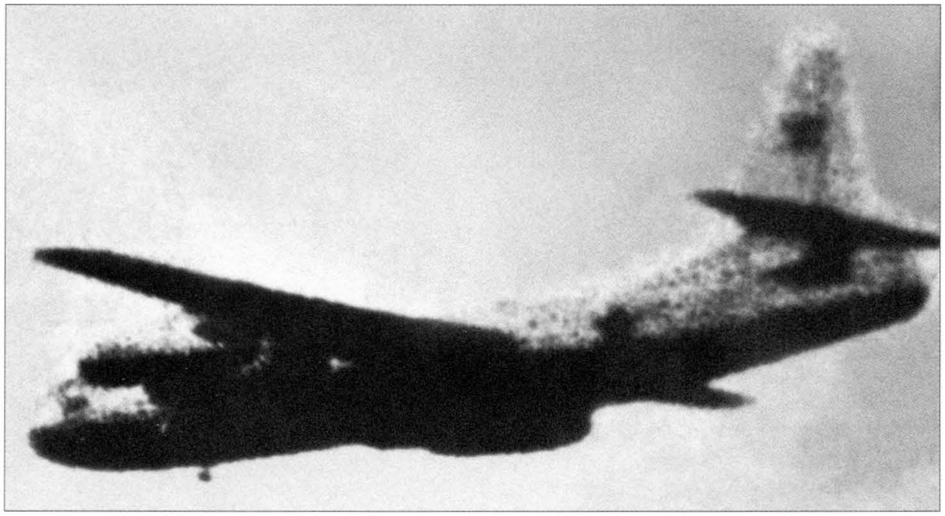
Above: A cutaway drawing of the IL-22 from the project documents, showing the retracted position of the mainwheels above the bomb bay and the three fuel tanks ahead of, above and aft of the bomb bay. Note the aerial above the tail gunner's station which was not fitted to the actual aircraft.

upper hemisphere and was controlled electrically by the radio operator, electric motors being used for both traversing and elevating. The cannons were slaved to the gunsight in the dorsal blister; special microswitches interrupted the cannon fire when the barrels pointed aft so as to avoid shooting up the bomber's own tail. The gunsight automatically compensated for the barbette's target lead, shell ballistics and parallax; all the gunner had to do was get the target into the crosshairs, track it and open fire at the right time.

The remote control system made it possible to optimise the relative position of the gunner and his weapons so as to provide them with the best field of view and the biggest field of fire respectively. Placing them apart allowed the barbette to be made much more compact and consequently less draggy. Also, the remote control principle increased the defensive weapons' accuracy appreciably because, firstly, the cannons were more rigidly attached to their mounts; secondly, the gunsight did not vibrate due to the recoil and could track the target more smoothly; and, finally, the gunner was less susceptible to fatigue. On the other hand, the remote control system was fairly complicated and thus generated errors itself; these errors could be calculated and compensated for but were best



A three-view drawing of the IL-22.



This poor-quality but interesting shot shows the IL-22 performing at the Aviation Day flypast at Moscow-Tushino on 18th August 1947. Note that star insignia have been applied.

reduced by keeping the barbette's control system simple.

A comparison of several defensive armament layouts showed that the remote control system really came into its own when the gunner and his weapons were placed at the aft extremity of the fuselage (ie, aft of the tail unit); in that case no 'blind spots' were created by the aircraft's structure and the system itself was comparatively simple and reliable. Realising the importance of creating a highly effective tail barbette and all that goes with it, Chief Designer Sergey V. Ilyushin took the decision to design the tail barbette in-house, despite the fact that defensive weapons systems were the domain of specialised design bureaux in the USSR.

Originally, in an effect to minimise the aircraft's drag, it was envisaged that the tail gunner would control his weapons from a prone position; yet this proposal was quickly rejected because it impaired the gunner's field of view, especially to the sides and upwards. In the definitive version of the tail gunner's station the gunner sat in the normal way and enjoyed an unrestricted field of view. This relative position of the gunner and the barbette was retained on nearly all Ilyushin aircraft featuring a tail gunner's station.

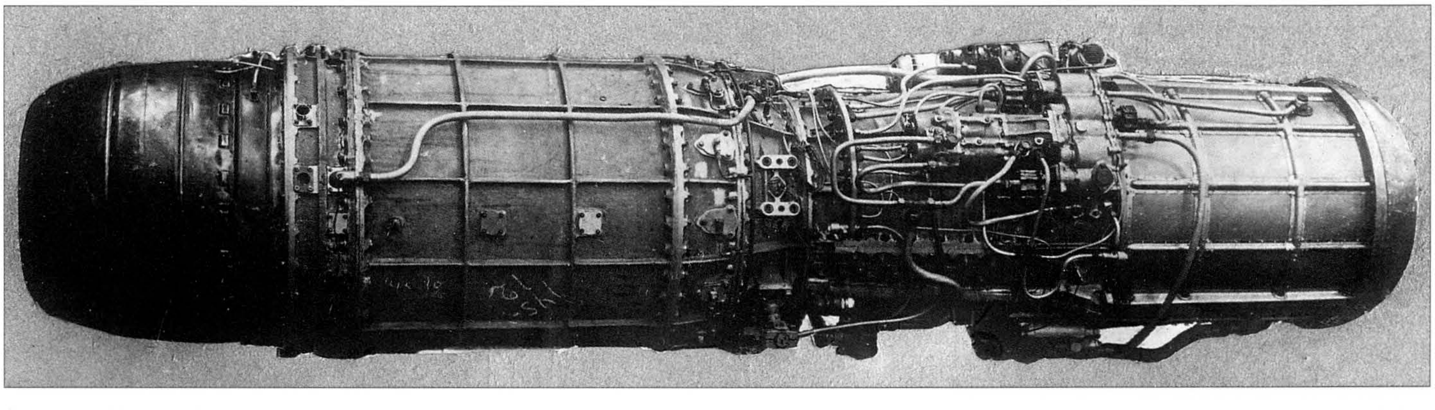
Designated IL-KU3 (for *kormo**va**ya oosta**nov**ka* – rear [defensive armament] installation), the barbette mounted an NS-23 cannon which traversed through ±70°, with a maximum elevation of 35° and a maximum depression of 30°. It was powered hydraulically by means of a hydraulic pump unit driven by a 1.7-kW electric motor and separate hydraulic rams for traversing and elevating. To facilitate aiming the tail gunner's seat could be raised and lowered by means of a separate electric motor.

On 31st January 1947 a special MAP expert panel signed its approval of the IL-22 ADP. Completion of the manufacturing drawings and prototype construction proceeded at a very brisk pace. On 28th-29th June 1947 the completed prototype was trucked from Moscow-Khodynka to the flight test facility in Zhukovskiy where, after reassembly, preparations for the maiden flight began. The manufacturer's flight tests officially commenced on 19th July; five days later the aircraft became airborne for the first time, flown by captain Vladimir K. Kokkinaki, co-pilot Konstantin K. Kokkinaki and flight engineers M. G. Kirsanov and I. B. Küss. Yakov A. Kutepov was assigned to the programme as engineer in charge of the tests.

As already mentioned, with the specified take-off thrust the IL-22 was to have a normal TOW of 24 tons (52,910 lb). In reality, however, the TR-1 turbojets delivered only 1,300 kgp (2,865 lbst) for take-off instead of the required 1,500-1,600 kgp (3,300-3,530 lbst), forcing the take-off weight to be limited to 20 tons (44,100 lb) during the manufacturer's flight test stage. At 1.27-1.35 kg/kgp·hr (lb/lbst·hr), the engines' specific fuel consumption turned out to be rather higher than expected, too. The low thrust/weight ratio and high SFC adversely affected the aircraft's performance: the take-off run was 1,144 m (3,753 ft), the range turned out to be a mere 865 km (537 miles) and the endurance just 1 hour 25 minutes. Top speed was 656.5 km/h (407.75 mph) at sea level and 718 km/h (446 mph) at 7,000 m (22,965 ft). In fairness, these figures basically met the manufacturer's estimates if one makes due corrections for the lower thrust and increased SFC; yet these figures could not satisfy anyone, of course.

The pilots' first impression of the IL-22 was unexpectedly good. Vladimir K. Kokkinaki reported that *'the aircraft is easy to fly and very responsive to control inputs. [The yaw caused by] throttling back one of the outer engines is easily countered by a slight deflection of the rudder and a turn of the control wheel and virtually does not cause an increase in control forces. The large volume of the fuselage makes itself felt during landings in a crosswind, but the sideslip is easily corrected by slight bank. The aircraft possesses excellent aerodynamics. The aircraft is underpowered, which has an effect on performance and handling, but this is easy to correct in the future.'*

The test pilots further noted that, with two or four engines running, the aircraft had a smooth ride on the ground thanks to the good oleo struts and had excellent ground manoeuvrability. The take-off was extremely straightforward, if rather protracted due to the insufficient engine power. In level flight the bomber displayed no abnormalities, maintaining straight and level flight even with the controls released if properly trimmed. Flying the IL-22 was not tiresome.



Starboard-side view of the TR-1A turbojet. Note the stiffening ribs on the engine casing.

In the event of a sudden engine failure, especially if the No.1 or No.4 engine was involved, the aircraft would yaw sharply in the direction of the dead engine, but normal flight could be restored with scarcely any extra pressure on the rudder pedals. The forces created by the thrust asymmetry were so slight that there was no need to adjust the rudder trim. Flying the aircraft with the Nos 1 and 4 engines shut down presented no problems either.

The landing approach was nothing out of the ordinary. After flareout the bomber created an air cushion due to the short-legged undercarriage, which eased the procedure considerably. The IL-22 showed no tendency to snake during the landing roll.

Yet the pilots also pointed out a number of shortcomings. In particular, the chosen forward fuselage design turned out to be unsatisfactory; the glazing framework obscured large areas and the curved glazing panels created annoying reflections and distorted the view. It turned out that, since the gunner's station was located well away from the barbette, some areas where the cannons could be brought to bear on the target were concealed from the gunner's view by the wings and fuselage.

It is worth noting that the twin-engined Tupolev Tu-12 (alias '77'), a heavily modified Second World War-vintage Tu-2 bomber refitted with Rolls-Royce Nene 1 centrifugal-flow turbojets and a nosewheel landing gear, made its first flight almost concurrently with the IL-22. Still, the Ilyushin bomber was the first past the post.

On 18th August 1947 the IL-22 was demonstrated at the annual Aviation Day air parade at Moscow-Tushino. Until the end of September it made several more test flights (mainly for the purpose of assessing its performance, handling and powerplant operation).

Stage A of the manufacturer's flight tests ended on 22nd September 1947. After the original TR-1 engines, which had reached the limit of their service lives, had been replaced with a fresh shipset and minor changes made to the control system, Stage B of the manufacturer's flight tests began, continuing until 27th February 1948. It involved powerplant testing in low ambient temperatures, comparative evaluation of different types of barbette actuators etc. In the opinion of the test crews, both of the barbettes' remote control systems (electric and hydraulic) served their purpose adequately; the electrically powered dorsal barbette was easy to aim and the inertia overshoots of the barbette when the gunsight was turned abruptly through large angles were small. The hydraulically powered tail barbette likewise required only small control forces; the controls were very sensitive and it took the gunner a while to adjust to them. The tail barbette's control system turned out to be more reliable than the electric actuators of the dorsal barbette.

Stage B included jet-assisted take-offs with the help of two SR-2 solid-fuel jet-assisted take-off (JATO) boosters attached to the rear fuselage sides; the boosters gave an initial impulse of 1,500 kgp (3,300 lbst) each. On 7th February 1948 Ilyushin OKB chief test pilot Vladimir K. Kokkinaki made the first-ever take-off with JATO boosters in the Soviet Union, flying the IL-22. Several such flights were made with varying take-off weights, demonstrating that field performance improved appreciably: the take-off run was reduced by 38% and the take-off distance to an altitude of 15 m (50 ft) by 28%. The test pilots stressed that operations with JATO boosters were simple and safe if the manual was observed, recommending that such boosters be used on other heavy jet aircraft as well.

Yet even at this stage the Lyul'ka OKB did not succeed in obtaining the required thrust from the TR-1 turbojet, which meant that the bomber could not meet its performance target. Hence submitting the IL-22 for State acceptance trials was deemed inexpedient and the programme was terminated. For a while the aircraft was on display at the New Equipment Bureau (BNT – *Byuro novoy tekhniki*), a section of TsAGI, where prominent Soviet aviation industry specialists had a chance to examine it. The designation IL-22 was reused (albeit much later) for an airborne command post derivative of the IL-18D turboprop airliner.

IL-24 tactical bomber project (first use of designation)

On 26th June 1946, when the Ilyushin OKB was in the process of developing the IL-22 bomber, the Ministry of Aircraft Industry issued an order envisaging the development of a new bomber designated IL-24 and powered by two Mikulin TKRD-1 axial-flow turbojets; this engine (also known as AM-TKRD-1) was rated at 3,300 kgp (7,275 lbst) for take-off. Yet OKB-240 had more urgent business to complete first, and it was not until November 1946, when development of the IL-22 had been finished, that the OKB started PD studies on a new tactical bomber having a top speed of 900 km/h (559 mph) and a range of about 2,000 km (1,240 miles). Originally the IL-24 was effectively a re-engined IL-22 featuring heavier defensive armament, with appropriate changes to the performance and weights; the airframe design and external dimensions were basically the same.

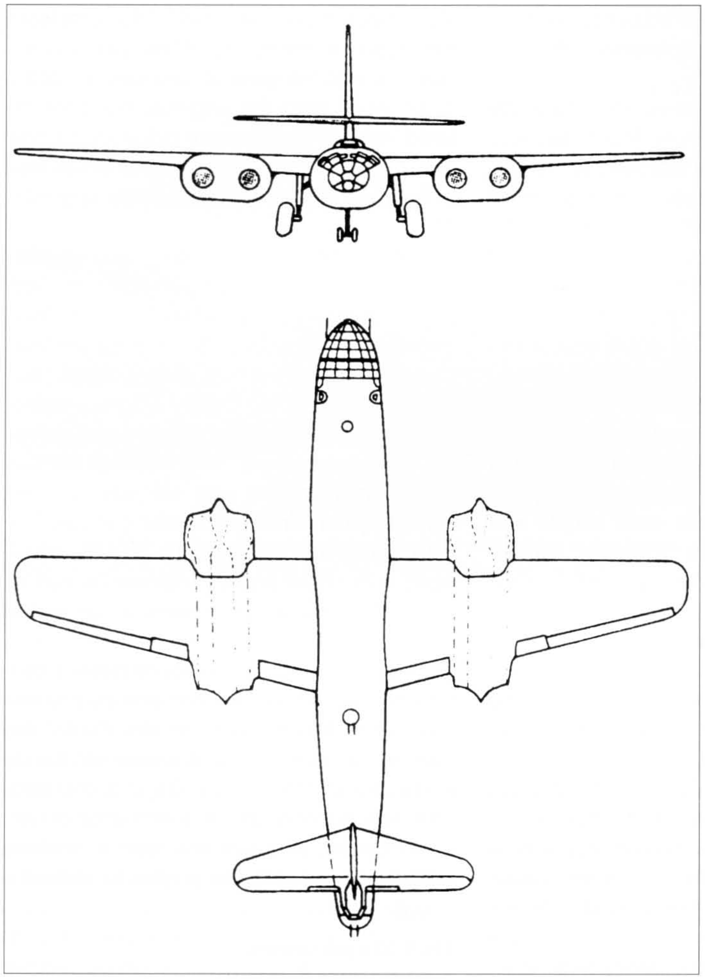
On 11th March 1947 the Council of Ministers passed a directive concerning the development of the IL-24 medium bomber powered by two AM-TKRD-1 turbojets; the aircraft was to commence State acceptance trials in September 1947. OKB-240 completed the project in the spring of that year; the aircraft retained the general arrangement of the IL-22. Apart from the engines, the IL-24 differed from the predecessor in featuring a new IL-KU-4 twin-cannon tail barbette which was to improve its defensive capability appreciably.

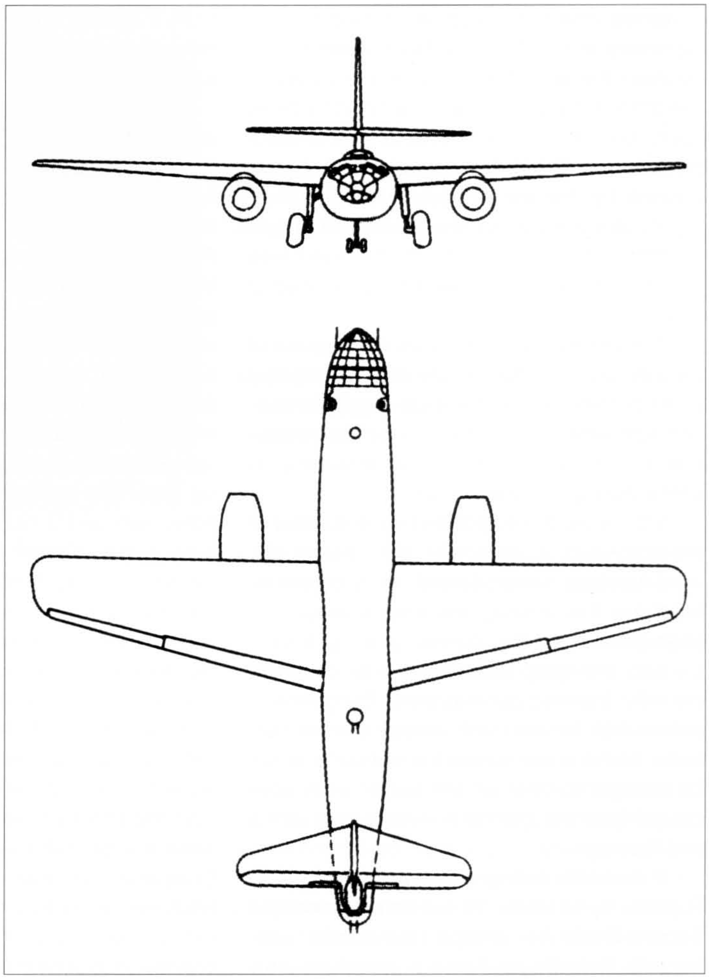
Chief Designer Sergey V. Ilyushin endorsed the project on 16th May; on 30th May it received the go-ahead from an MAP expert panel. Yet the project was not destined to materialise in this form; MAP took the decision to divert the AM-TKRD-1 engines intended for the IL-24 to OKB-1 headed by Semyon M. Alekseyev where '140' tactical bomber whose development was officially commissioned by the ministry was taking shape. The '140' (originally the Junkers EF 140) developed under chief project engineer Brunolf W. Baade featured forward-swept wings and is described later in this book.

Meanwhile, the Rolls-Royce Nene 1 centrifugal-flow turbojet entered licence production in the Soviet Union as the RD-45; the licence-built version had a longer service life and a take-off thrust of 2,270 kgp (5,000 lbst). This was not enough for a twin-engined aircraft of the IL-24's size and weight, and the OKB had to rework the project to feature a

The IL-22's performance (manufacturer's flight tests)

Length overall	21.05 m (69 ft¾ in)
Wing span	23.06 m (75 ft 7⅞ in)
Wing area, m^2 (sq ft)	74.5 (801)
Normal take-off weight, kg (lb):	
target figure	24,000 (52,910)
actual	20,000 (44,100)
Empty weight, kg (lb)	14,950 (32,960)
Fuel load, kg (lb)	9,300 (20,500)
Bomb load, kg (lb):	
normal	2,000 (4,410).
maximum	3,000 (6,610)
Top speed, km/h (mph):	
at sea level	656.5 (407.75)
at 5,000 m (16,400 ft)	705 (437)
at 7,000 m (22,965 ft)	718 (446)
Landing speed, km/h (mph)	190 (118)
Time to altitude, minutes:	
to 5,000 m (16,400 ft)	8.6
to 8,000 m (26,246 ft)	17.4
Service ceiling, m (ft)	11,100 (36,420)
Range with a 2,000-kg bomb load at 4,900 m (16,080 ft) and a cruising speed of 485 km/h (301 mph)	865 (537)
Take-off run, m (ft)	1,144 (3,753)
Landing run, m (ft)	940 (3,080)
Defensive armament:	
20-mm cannons	2
23-mm cannons	2



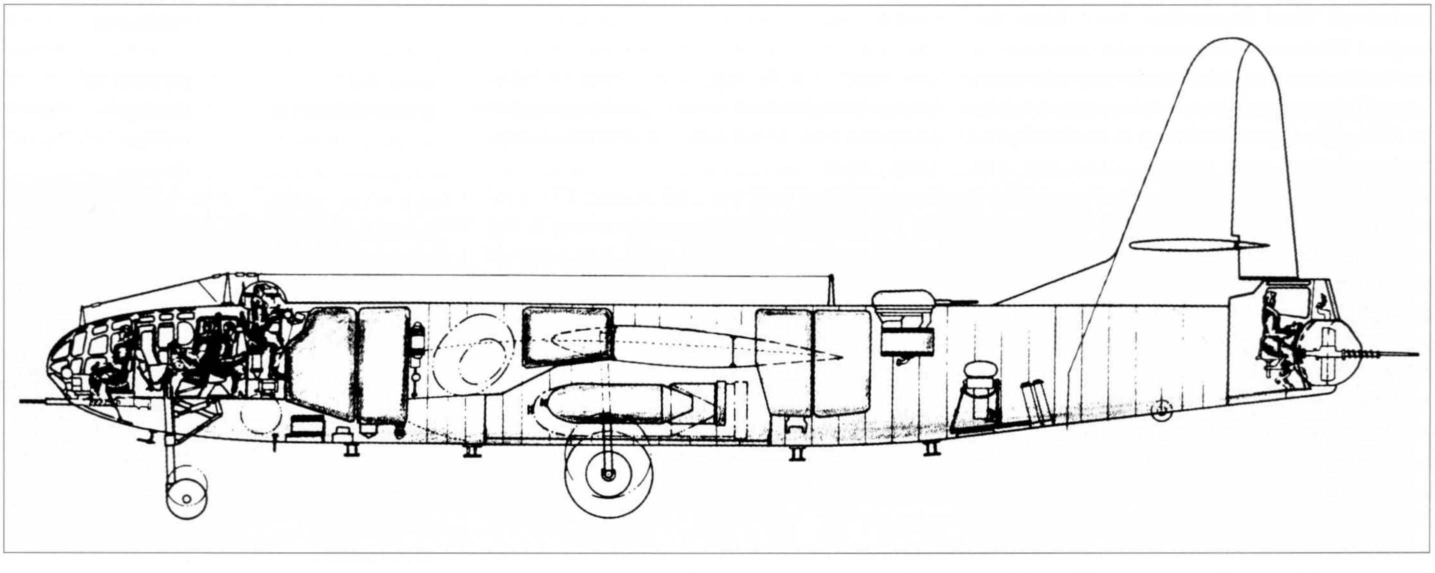


Above: The IL-24 was projected with two alternative powerplants. The views on the left show the version powered by four Rolls-Royce Nene Is in paired nacelles and looking like a scaled-up Arado Ar 234C; the version on the right is powered by two Mikulin AM-TKRD-1s.

powerplant consisting of four RD-45s. Yet, whatever engine type was used, the IL-24 was going to be very heavy; the RD-45-powered version grossed at 28 tons (61,730 lb), which made it unsuitable for operation from unpaved strips – and paved runways were still scarce in the USSR at the time.

All things considered, on 21st June 1948 the Council of Ministers issued a directive cancelling the IL-24 programme. By then the prototype was 65% complete.

After analysing the results of the IL-22's tests and the course of the IL-24's design work, Sergey V. Ilyushin resolutely (as was his wont) terminated all further work in this direction and embarked on a new tactical bomber project which eventually materialised as the highly successful IL-28. As for the IL-24 designation, it was again reused for a specialised long-range ice patrol derivative of the IL-18D.



A cutaway drawing of the IL-24 from the project documents.

Chapter 2

Myasishchev's Hopes

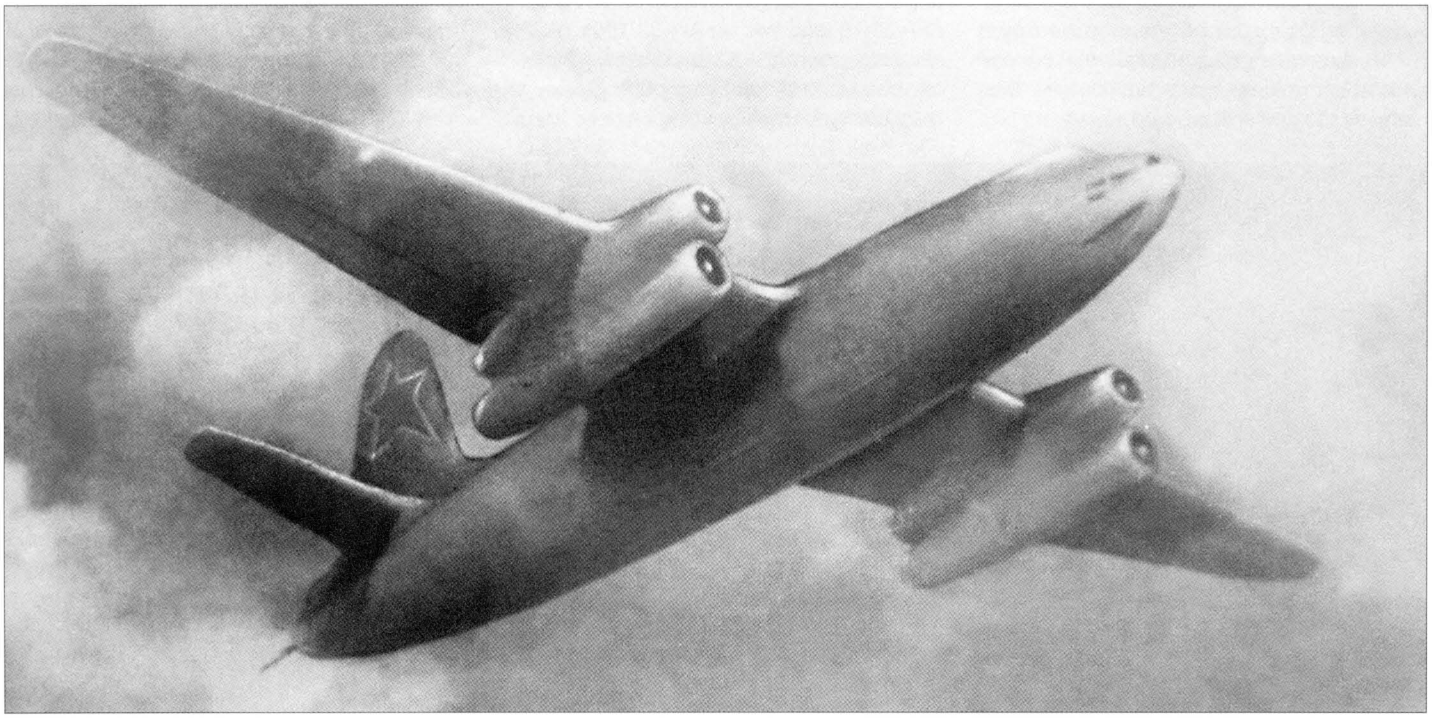
DSB-17 fast day bomber project (IDD-17, RB-17, VM-24)

As the Soviet aircraft industry commenced its efforts to create jet bombers, the famous aircraft designer Vladimir Mikhaïlovich Myasishchev was ahead of the gang. The other Soviet aircraft designers took on the task eighteen months, two years or even three years later. As it turned out, these innovative aspirations cost him dearly; not wishing to see an 'eager beaver' complete the job ahead of them (Myasishchev intended to test his jet bomber as early as the summer of 1946), some of his influential competitors conspired to set up Myasishchev's OKB-482 and have it closed down with the official justification that it was 'unnecessary in the peacetime.' Aleksandr S. Yakovlev, who was then Deputy People's Commissar (ie, Minister) of the Aircraft Industry and Iosif V. Stalin's principal authority on aviation matters, personally made a list of design bureaux which were to be liquidated in the second half of the 1940s and presented it to the Soviet leader for appraisal. The liquidation of these enterprises (with the 'survivors' in the industry fighting over the scraps) proceeded under the slogan 'The war is over, excess is damaging!' To quote from a song by Dire Straits, *'Treachery and treason, // There's always an excuse for it, // And when I find the reason, // I still cannot get used to it.'*

Thus the existence of OKB-482 was terminated when the Soviet Union's first truly indigenous jet bomber was in the opening stages of its development. Officially designated DSB-17 (*dnev**noy** skoros**noy** bombardi**rov**shchik* – fast day bomber) in keeping with the pre-war system of Soviet aircraft designations, the aircraft was known in house as the VM-24 – that is, Vladimir Myasishchev, Project 24. The design work began in the autumn of 1945 and was performed with typical Myasishchev elegance and attention to detail.

Creating a heavily armed jet bomber capable of carrying a 3-ton (6,610-lb) bomb load over a distance of 1,000 km (620 miles) at a speed some 150-200 km/h (93-124 mph) greater than that of contemporary propeller-driven bombers was an extraordinarily complicated task in its day. This was due first and foremost to the newness of the subject, with no previously built aircraft and statistical data (in the Soviet Union, that is) to fall back on. This necessitated a huge amount of research in a variety of aerodynamic, structural strength and general arrangement matters. The high speed required for the jet bomber could be attained by utilising a high wing loading and thin wings with a high critical Mach number to delay the onset of the shock wave crisis. Another problem was that the required long range and high payload led to a dramatic increase of the aircraft's all-up weight and dimensions due to the need to carry a lot of fuel (the fuel load accounted for more than 40% of the AUW versus 15-22% in the case of piston-engined bombers). As already noted, the available turbojet engines – the Junkers Jumo 004B and BMW 003A – had a static thrust of only about 800-900 kgp (1,760-1,980 lbst) at sea level, which certainly did not help.

At the ADP stage the DSB-17 was an all-metal monoplane with shoulder-mounted unswept wings and unswept tail surfaces; the tricycle landing gear retracted into the fuselage. The crew of three (pilot, navigator/bomb-aimer and gunner) was accommodated in two pressurised cabins, since the aircraft was to operate at altitudes of 9,000-11,500 m (29,530-37,730 ft). The pilot sat in the left-hand seat, with the navigator/bomb-



An artist's impression of the DSB-17 (RB-17) from the project documents, showing the vertically paired engines with no horizontal stagger.

Estimated range of the DSB-17 bomber

Range, km (miles)	TOW, kg (lb)	Bomb load, kg (lb)	Fuel load, kg (lb)	Altitude, m (ft)	Speed, km/h (mph)
1,600 (990)	14,410 (31,770)	2,000 (4,410)	4,245 (9,360)	11,000 (36,090)	680 (422)
3,000 (1,860)	14,410 (31,770)	1,000 (2,205)	7,000 (15,430)	11,000 (36,090)	680 (422)
1,900 (1,180)	19,200 (42,330)	3,000 (6,610)	3,500 (7,720)	8,000-9,000 (26,250-29,530)	600 (372)

aimer sitting slightly ahead and below him; the forward cabin afforded a good field of view thanks to the wide canopy and the forward and lateral glazing of the navigator's station. The forward cabin was accessed via a door with a small window on the starboard side; below the cabin was the unpressurised nosewheel well, the space above the retracted nosewheel being occupied by a self-sealing fuel tank.

The bullet-shaped forward fuselage section with a parabolic contour terminated in a mating flange; it was bolted to an elliptical-section centre fuselage section which was 6 m (19 ft 8¼ in) long. Three self-sealing fuel tanks of inverted-U cross-section (each split into two halves) and the wing centre section carry-through structure occupied the upper half of it (above the fuselage waterline). The lower half accommodated the bomb bay, aft of which were the mainwheel wells; the aft-retracting main units had single wheels. The rear fuselage housed control runs, piping and wiring; it incorporated the gunner's pressurised cabin and attachment points for the tail surfaces.

The powerplant arrangement was probably the most unconventional feature of the proposed bomber. Four Jumo 004B axial-flow turbojets (or, to be precise, the Soviet RD-10 reverse-engineered version) were carried under the wings, paired vertically in deep nacelles situated well inboard.

The DSB-17 was to carry a normal bomb load of 1,000-2,000 kg (2,205-4,410 lb), with a maximum bomb load of 3,000 kg. The ordnance load varied according to the mission, as illustrated in the table above.

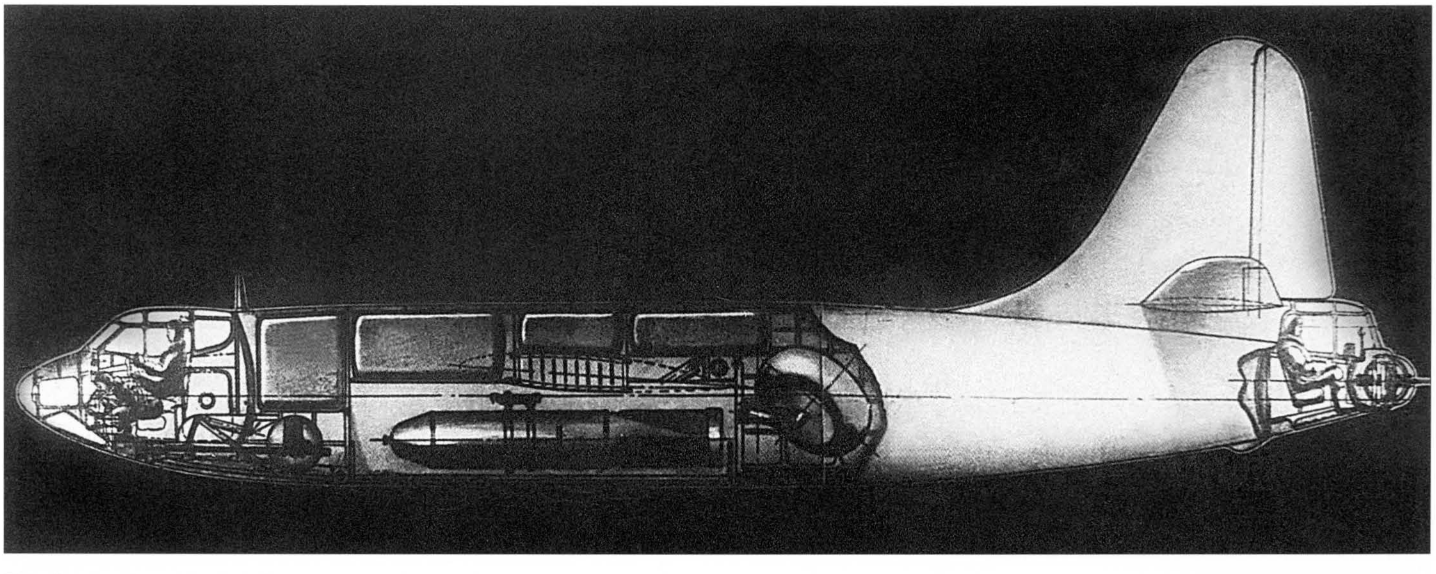
The defensive armament comprised a fixed forward-firing Nudelman/Suranov NS-23 cannon with 150 rounds and a DEU tail barbette with a Berezin B-20 cannon (or, alternatively, a DKU barbette with a second NS-23) with 200 rounds. The pilot and navigator/bomb-aimer were protected by 15-mm (19/32 in) steel armour sheets, while the gunner's station featured 10-mm (13/32 in) armour and bulletproof glass panes 64 mm (2½ in) thick; the total weight of the protective armour was 185 kg (407 lb).

The DSB-17 day bomber was to have other applications as well, one of them being the IDD-17 long-range fighter (*istre**bit**el' **dahl'**nevo **dey**stviya*) intended for air defence duties. In this version the bomb bay was to be adapted for housing an extremely powerful battery of cannons; the calibre ranged from 20 mm (0.78 in) to 57 mm (2.24 in) and even 75 mm (2.95 in). A further version designated RB-17 (*raz**ved**chik-bombardi**rov**shchik*) was a reconnaissance/strike aircraft. The bomb bay housed four cameras – an AFA-3S, an AFA-33/75 and two AFA-4-33/100s (AFA = ***a**ero**fot**oappa**raht*** – aerial camera) – for vertical, oblique and combined photography, the latter being enabled by tilting camera mounts. The bomb load was reduced to 800 kg (1,760 lb) and was carried externally under the inner wings.

The advanced development project was submitted for review to NKAP and GK NII VVS. Both institutions blasted the DSB-17's aerodynamic and weight layout furiously, but Myasishchev stood up to the withering criticism. He knew what he was doing. The wings had been designed in close co-operation with TsAGI to select the optimum aspect ratio and airfoils. The very thin wings of relatively short span with slight leading-edge sweep had a high aspect ratio (8 or 9) and featured exceptionally powerful high-lift devices by the day's standards. The paired engines were carried on bearers projecting beyond the wing leading edge at 35% span. The use of high aspect ratio wings which were not off-loaded by the weight of internal fuel, coupled with the low thickness/chord ratio (12%) and the danger of aileron reversal at high speeds, necessitated the use of new high-strength alloys, as structural strength calculations showed.

The high wing loading and the low engine thrust would result in a longer take-off run as compared to piston-engined aircraft. Hence Vladimir M. Myasishchev had made provisions for solid-fuel JATO boosters to reduce the take-off distance.

There was room for only two engine attachment points under the DSB-17's wings, which forced Myasishchev to use vertically



This diagram illustrates the DSB-17's internal layout. The size of the mainwheels is noteworthy.

paired engines. Yet this cunning approach illustrated his firm conviction that more advanced and powerful turbojets that would give the aircraft an acceptable thrust/weight ratio with two engines instead of four would appear in just a couple of years. He was right. In 1946-47 the Soviet Union bought licences to manufacture the Rolls-Royce Nene I and the Rolls-Royce Derwent V, which were quickly put into production as the RD-45 and the RD-500 respectively. These engines had adequate thrust to replace the paired German engines around which the DSB-17 had been designed.

DSB-17 specifications (estimated)

Year of manufacture	1945	1946
Powerplant	4 x RD-10	2 x RR Derwent V
Engine thrust, kgp (lbst)	4 x 900 (1,980)	2 x 1,695 (3,740)
Length overall (fuselage horizontal)	16.06 m (52 ft 8¼ in)	16.06 m (52 ft 8¼ in)
Wing span	20.8 m (68 ft 2⅞ in)	20.8 m (68 ft 2⅞ in)
Tailplane span	6.48 m (21 ft 3⅛ in)	6.48 m (21 ft 3⅛ in)
Wing area, m^2 (sq ft)	48.0 (516.1)	48.0 (516.1)
Distance between engine axes	6.0 m (19 ft 8¼ in)	6.0 m (19 ft 8¼ in)
Landing gear track	2.844 m (9 ft 4 in)	2.844 m (9 ft 4 in)
Landing gear wheelbase	5.76 m (18 ft 10¾ in)	5.76 m (18 ft 10¾ in)
Top speed, km/h (mph):		
at sea level	725 (450)	710 (441)
at 5,000 m (16,400 ft)	805 (500)	820 (509)
Climb time to 5,000 m, minutes	9.0	8.0
Service ceiling, m (ft)	11,500 (37,730)	12,800 (42,000)
Range, km (miles):		
with standard fuel	1,600 (990)	1,800 (1,120)
with maximum fuel	3,000 (1,860)	4,000 (2,480)
Empty weight, kg (lb)	9,450 (20,830)	8,280 (18,250)
All-up weight, kg (lb):		
with standard fuel	14,410 (31,770)	12,700 (28,000)
with maximum fuel	19,212 (42,354)	17,600 (38,800)
Fuel load, kg (lb):		
normal	4,250 (9,370)	4,500 (9,920)
maximum	7,000 (15,430)	7,000 (15,430)

The Report on the ADP, which was endorsed by the Red Army Air Force's Chief Engineer Col. Gen. A. Repin on 2nd February 1946, read:

'The aircraft submitted for review in advanced development project form is the first indigenous jet bomber and is of interest to the Red Army Air Force. According to the performance figures stated in the ADP, the aircraft is markedly superior to production piston-engined bombers, namely:

a) the top speed is 250-275 km/h [155-170 mph] *higher;*

b) the service ceiling is 2,000-3,000 m [6,560-9,840 ft] *greater.'*

At the mock-up review stage (the full-scale mock-up was completed in RB-17 form) the mock-up review commission considered the landing gear track to be inadequate for ensuring lateral stability during ground manoeuvring and especially during landings in a crosswind. Apart from a few minor criticisms relating to operational procedures, however, the commission's reaction was generally favourable.

Detail design work on the DSB-17 commenced immediately after the endorsement of the ADP in early December 1945. Despite a wing loading of 300-400 kg/m^2 (61.5-82.0 lb/sq ft) and a thrust/weight ratio of 0.25 – the aircraft had a wing area of 48 m^2 (516 sq ft) and an aggregate engine thrust of about 3,700 kgp (8,160 lbst), – the bomber was expected to possess good field performance. With four JATO bottles developed by I. I. Kartukov, the take-off run with a take-off weight of 16,400 kg (36,155 lb) was to be no more than 870 m (2,850 ft); with a 10,300-kg (22,710-lb) landing weight, the landing run would be kept down to 550 m (1,800 ft) by using a brake parachute.

Sadly, the DSB-17 tactical bomber never received its intended engines. The authorities did not let Myasishchev build and test his first jet, and the fact that OKB-482 was commended and many of its employees received government awards for their 'major achievements in creating new aircraft' was but cold comfort. Very probably the chiefs of the competing design bureaux, realising that they could not possibly keep up with Myasishchev, resorted to the traditional means of socialist competition to trip up the 'young upstart'. Or, equally possibly, the reason lay in the fact that Myasishchev, who had been arrested and convicted in 1938 during Stalin's purges, was not yet amnestied (this happened in 1953, after Stalin's death), much less exonerated (this did not occur until 1956), and thus was considered 'not trustworthy enough' to allow him to build such strategically important hardware.

Anyway, before OKB-482 had a chance to procure any RD-45s or RD-500s it was subordinated to Sergey V. Ilyushin, Chief Designer of OKB-240. On 1st February 1946 the Soviet Council of Ministers issued directive No.2548-1065 terminating all further work on bombers at the design bureaux headed by Igor' V. Chetverikov and Vladimir M. Myasishchev. Shortly afterwards, in keeping with an order issued by Minister of Aircraft Industry Mikhail V. Khrunichev on 20th February 1946, OKB-240 took over the entire facilities and staff of OKB-482 which was conveniently located right next door at Moscow's Central Airfield named after Mikhail V. Frunze (alias Moscow-Khodynka).

The following is a brief structural description of the DSB-17.

Type: Four-engined three-seat tactical aircraft designed for operation as a fast day bomber (DSB-17), a reconnaissance/strike aircraft (RB-17) or a long-range interceptor (IDD-17). The airframe was of all-metal construction.

Fuselage: Semi-monocoque structure of elliptical cross-section with the longer axis horizontal; maximum width 2,500 mm (8 ft 2½ in), maximum height 2,000 mm (6 ft 6¾ in). The fuselage framework consisted of main and auxiliary frames, four longerons and a set of stringers.

Structurally the fuselage consisted of three sections: forward, centre and rear. The *forward fuselage* incorporated the forward pressurised cockpit (featuring a dorsal canopy and nose glazing), the nosewheel well, the forward-firing cannon installation and the forward fuel tank.

The cockpit featured staggered tandem seating for the pilot and the navigator/bomb-aimer sitting ahead of and below him; it was accessible via a door on the starboard side and featured double glazing demisted by forcing warm air between the inner and outer panes. Crew evacuation in an emergency was possible both via the entry door and via a jettisonable section of the canopy roof. The inside of the cockpit was faced with heat- and soundproofing mats.

The *centre fuselage* incorporated the wing centre section, the bomb bay, the mainwheel wells and accommodated fuel tanks. The twin bomb bay doors opened inwards to lie flat against the walls.

The *rear fuselage* accommodated the pressurised gunner's compartment (accessible via a jettisonable side door) and tail gun barbette; it also incorporated the tail unit attachment fittings.

Wings: Cantilever mid-set monoplane wings of basically trapezoidal planform. Sweepback at quarter-chord 0°, slight constant leading-edge sweep from roots. The wings were three-spar structures utilising TsAGI high-speed airfoils; thickness/chord ratio 12%. Engine bearers were attached to the spars at 35% of the span. The wings were equipped with trailing-edge flaps and ailerons incorporating electrically actuated trim tabs.

Tail unit: Cantilever cruciform tail surfaces with no sweepback; stabiliser dihedral 8°. The variable-incidence horizontal tail was raised to avoid Mach buffet and keep it clear of the engine exhaust; incidence was adjusted electromechanically and controlled by a switch in the cockpit.

The narrow-chord rudder and elevators had both aerodynamic and mass balancing and featured electrically actuated trim tabs. The horizontal and vertical tail area made up 18% and 14% respectively of the wing area.

Landing gear: Electrohydraulically retractable tricycle type, with hydraulic emergency extension by means of a hand-driven pump; all units retracted aft into the fuselage. The wheel wells were completely closed by doors, the main doors opening only when the gear was in transit.

All three landing gear struts had oleo-pneumatic shock absorbers. The nose unit was equipped with twin 650 x 200 mm (25.59 x 7.87 in) wheels and a shimmy damper; the main units had single 1,200 x 450 mm (47.24 x 17.7 in) wheels. All wheels were equipped with hydraulic brakes; the mainwheel brakes were controlled by the rudder pedals and the nose gear steering mechanism by a lever on the instrument panel.

A brake parachute housed in a special bay on the aft fuselage underside was provided to shorten the landing run.

Powerplant: Four RD-10 (Junkers Jumo 004B1) axial-flow turbojets rated at 900 kgp (1,980 lbst) for take-off, with a cruise rating of 400 kgp (880 lbst) at 8,000 m (26,250 ft) and maximum speed. The engines were housed in vertical pairs in common nacelles ahead of the wing leading edge and attached to truss-type engine bearers.

The RD-10 was a single-spool turbojet featuring an eight-stage compressor, a combustion chamber with six separate flame cans, a single-stage turbine and a variable nozzle with a translating conical centrebody. The fuel flow and nozzle centrebody position were controlled by a common throttle lever. Starting was by means of a Riedel two-stroke two-cylinder piston engine driving the spool directly via a clutch. Each engine featured its own 15-litre (3.3 Imp gal) oil tank.

Engine pressure ratio (EPR) 3.0; mass flow at take-off rating 23 kg/sec (50.7 lb/sec), turbine temperature 1,043° K, specific fuel consumption (SFC) 1.43 kg/kgp.h (lb/lbst.h). Length overall 3,935 mm (12 ft 11 in), casing diameter 810 mm (2 ft 7⅞ in), dry weight 720 kg (1,590 lb).

Provisions were made for two JATO booster rockets which were attached to the wing underside and jettisoned automatically after burnout.

Control system: Conventional mechanical flight control system with push-pull rods. The cockpit featured rudder pedals hinged at the top and a control column with a wheel.

Fuel system: All fuel was carried in seven self-sealing bag-type tanks – one in the forward fuselage and six in the upper centre fuselage; the normal fuel load was 4,250 kg (9,370 lb). Each tank featured an electric transfer pump. Provisions were made for six long-range tanks in the fuselage, increasing the total fuel load to 7,000 kg (15,430 lb).

The DSB-17's bomb load options

Model	Unit weight, kg (lb)	Quantity	Total weight, kg (lb)
M-45	3,000 (6,610)	1	3,000 (6,610)
M-44	2,000 (4,410)	1	2,000 (4,410)
M-44	1,000 (2,205)	2	2,000 (4,410)
M-44	500 (1,102)	4	2,000 (4,410)
M-44	250 (551)	8	2,000 (4,410)
	100 (220)	18	1,800 (3,970)

Old-generation bombs were to be carried in the following combinations

Model	Quantity	Total weight, kg (lb)
FAB-1000	1	1,000 (2,205)
FAB-500	1	500 (1,102)
FAB-250	8	2,000 (4,410)
FAB-100	18	1,800 (3,970)

Electrics: Main electric power provided by two 3-kW engine-driven DC generators; back-up DC power provided by a 12A30 (30 A·h) storage battery. Electric equipment included the motors of the electrohydraulic landing gear actuation system, the stabiliser trim mechanism, the aileron, elevator and rudder trim tab actuators, fuel transfer pumps and internal/external lighting.

Avionics and equipment:

Navigation/piloting equipment and cockpit instrumentation: Apart from the usual complement of flight instrumentation, the aircraft was to be equipped with a remote magnetic compass, a Bendix-type direction finder (DF), a radio altimeter and (RB-17) a Sperry-type autopilot providing stabilisation along all three axes and receiving inputs from the navigator's Norden bombsight.

The engine control instruments included a fuel flow meter, tachometers, exhaust gas thermometers, gas, air and oil manometers.

Communications equipment: RSB-5 communications radio, RSI-6 command link radio, SPUF-3 intercom and three-colour internal signal lights.

Targeting equipment: TON-3 navigation/bomb-aiming radar and Norden bombsight in the navigator's station;

IFF equipment: SCh-3 identification friend-or-foe (IFF) transponder.

Photo equipment: (DSB-17) AA-3S-1000 strike camera; (RB-17) two AFA-33/20 cameras on tilting mounts for multi-strip vertical photography and one AFA-33/75 for oblique photography.

Armament: The DSB-17 had a bomb bay permitting internal carriage of 'short' bombs of 100 to 1,000 kg (220-2,205 lb) calibre or a single 3,000-kg (6,610-lb) bomb. The envisaged offensive armament options are given in the table on this page.

The RB-17 was to carry 800 kg (1,760 lb) of bombs externally under the inner wings.

The IDD-17 fighter was armed with a ventral package of forward-firing cannons comprising two 23-mm (.90 calibre) Nudelman/Suranov NS-23s with 150 rounds per gun and two 57-mm (2.24 calibre) Roshkov Model 113P cannons with 25 rpg.

The defensive armament in all three variants comprised a fixed forward-firing NS-23 with 150 rounds and a DEU remote-controlled tail barbette mounting a 20-mm (.78 calibre) Berezin B-20 cannon (or a DKU barbette with an NS-23) with 200 rounds. The tail cannon was aimed by means of a collimator sight; cannon and sight movement was synchronised via an electromechanical synchro transmission.

Chapter 3

Denied the Chance to Fly

Sukhoi's First Jet Bomber

Su-10 tactical bomber (*izdeliye* Ye)

On 26th February 1946 the Soviet Council of People's Commissars issued a directive tasking the OKB headed by Pavel Osipovich Sukhoi (at that time, OKB-134) with developing and building a bomber powered by four 900-kgp (1,980-lbst) Junkers Jumo 004B turbojets. On 27th March that year the Minister of Aircraft Industry signed an order instructing Sukhoi (who was also Director of plant No.134 where his OKB was located at the time) to start development of the jet bomber.

Design work on Sukhoi's first jet bomber, which received the in-house designation *izdeliye* Ye (the sixth letter of the Cyrillic alphabet), began on 24th April 1946. (*Izdeliye* (product) such-and-such was, and still is, a common euphemism for Soviet/Russian military hardware types.) Later the aircraft was allocated the official designation Su-10. Concurrently with the PD studies the OKB issued manufacturing drawings for a preliminary wind tunnel model designated S-9.

Several powerplant arrangements were considered; in the original one the engines were mounted under the wings in vertically and horizontally staggered pairs. On 26th April the draftsmen delivered part of the drawings for the provisional cockpit section mock-up (those for the internal fuselage framework); the complete set of drawings for the wind tunnel model was delivered four days later.

No aerodynamic calculation techniques suitable for such an aircraft existed yet (or, at any rate, no ready-made theses in this field were available to Sukhoi in 1946), which meant OKB-134 had to develop aerodynamic and range calculation techniques for jet aircraft on its own. The result was a method which allowed the aircraft's range to be determined for any given speed and altitude.

The S-9 wind tunnel model was tested in TsAGI's T-106 wind tunnel with different wing-mounted engine arrangements featuring one, two or three engines on each wing. This research allowed the optimum layout to be selected for the Su-10; the highest critical Mach number was attained with the engine nacelles protruding beyond the wing leading edge and placed so that the nacelle's axis coincided with the wing chord. Thus in its ultimate form the Su-10 was a high-wing monoplane with unswept trapezoidal wings and four or six engines mounted in clusters of two or three on the wings.

The Su-10 was characterised by its large bomb load, all of which was carried internally. As regards weight/payload ratio the aircraft surpassed not only the Tupolev Tu-2, which was one of the best Soviet tactical bombers of the day, but also the most advanced American bombers, being second only to the Boeing B-29 Superfortress in the defensive armament's weight of fire. The table at the foot of this page gives a comparison of the Su-10 and some contemporary bombers. The small fuselage cross-section area as compared to the contemporary Ilyushin IL-22 bomber was due mainly to the different landing gear arrangement (the main gear units retracted inwards into the wing roots rather than forwards into the fuselage).

In order to meet the speed target of 850 km/h (528 mph) at 8,000 m (26,250 ft) stated in the officially approved Experimental Aircraft Construction Plan for 1946, Chief Designer Pavel O. Sukhoi decided to increase the number of RD-10 (Jumo 004B) turbojets powering the Su-10 from four to six. This resulted in neat but unconventional three-packs of engines adhering to the wing undersurface; two engines in each nacelle were placed side by side, with the third engine located slightly lower and ahead of them on the nacelle centreline. The stagger allowed the nacelle's height and cross-section to be minimised; the accessories of the three engines were positioned in line and the vertical distance between the engine axes was reduced. Also, the upper engines were installed with a slight toe-out to bring them closer together. The overall result was to cut drag and reduce the amount of metal necessary for the nacelle structure. Importantly, access to each engine for maintenance and change was very easy.

In another project version the Su-10 underwent an extensive redesign. Two of the six RD-10 engines were mounted low on the forward fuselage sides; the other two were buried in the centre fuselage in vertical pairs, breathing through large circular air intakes. The latter were partially recessed into the fuselage and divided by the wing spars into upper and lower ducts, one for each engine.

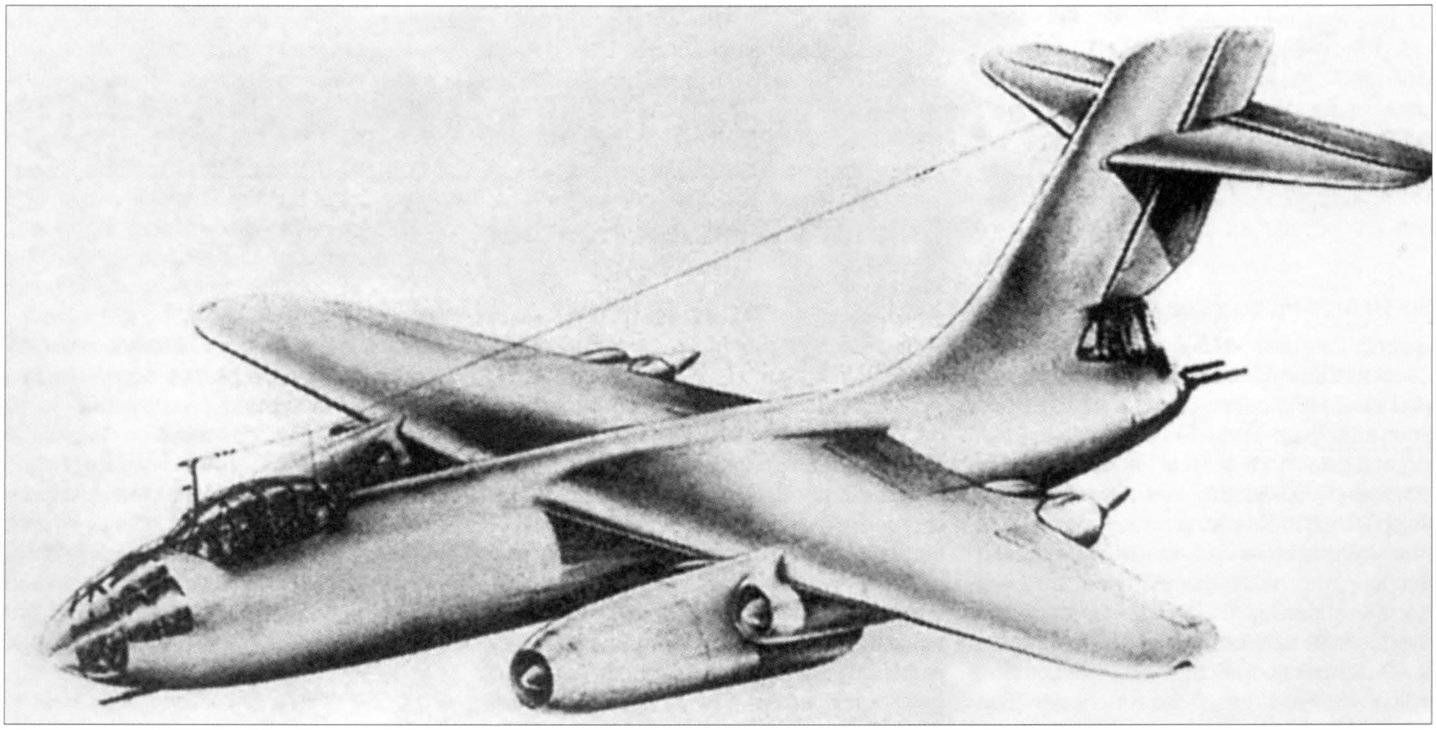
The fuselage was now much more portly, with an elliptical cross-section and a parabolic nose shape. To offset the increase in cross-section area the cockpit canopy was greatly reduced in size and offset to port, protruding only a little above the fuselage. A glazed twin-cannon 'ball turret' with an opaque forward fairing was mounted atop the centre fuselage; it was supplemented by a movable cannon in the nose and a tail gunner's station with twin-cannon powered tail turret. The main landing gear units retracting into the wing roots featured twin small wheels located in tandem.

On 6th May the OKB commenced design work on a full-scale engineering, manufacturing and development (EMD) mock-up with real engines that was to be used for engine-running tests in one of TsAGI's wind tunnels; the full set of drawings for the provisional cockpit section mock-up was completed that same day. Two days later the OKB's modelling department started manufacturing the first wind tunnel model and received the complete drawings for two models intended for testing in the TsAGI T-102 and T-106 wind tunnels respectively. The templates for the EMD mock-up were made in mid-May; the drawings of the associated test rig were delivered on 7th July.

A comparison of some bombers of 1945-46

Type	Fuselage cross-section area, m^2 (sq ft)	Maximum bomb load, kg (lb)	Weight of fire, kg (lb)	All-up weight, kg (lb)
Tupolev Tu-2	2.04 (21.93)	1,000/3,000 (2,205/6,610)*	4.2 (9.25)	10.380 (22,880)
North American B-25 Mitchell	2.7 (29.0)	2,370 (5,225)	4.8 (10.58)	12,900 (28,440)
Boeing B-29 Superfortress	6.6 (70.96)	9,100 (20,060)	9.2 (20.28)	54,430 (120,000)
Sukhoi Su-10	2.7 (29.0)	4,000 (8,820)	6.3 (13.88)	18,950 (41,780)

* Internal only/internal plus external



Above: This artist's impression illustrates an early project configuration of the Su-10 with four RD-10 engines under the wings. Note that the engines are staggered not only horizontally but also vertically, the inboard ones being placed lower than the outer ones. There was no dorsal turret yet at this stage.

On 19th June 1946 the Sukhoi OKB completed the ADP of the Su-10. Preliminary integration of the airframe and systems began on 1st July; on 19th July the wind tunnel model featuring the initial wing design was turned over to TsAGI for testing.

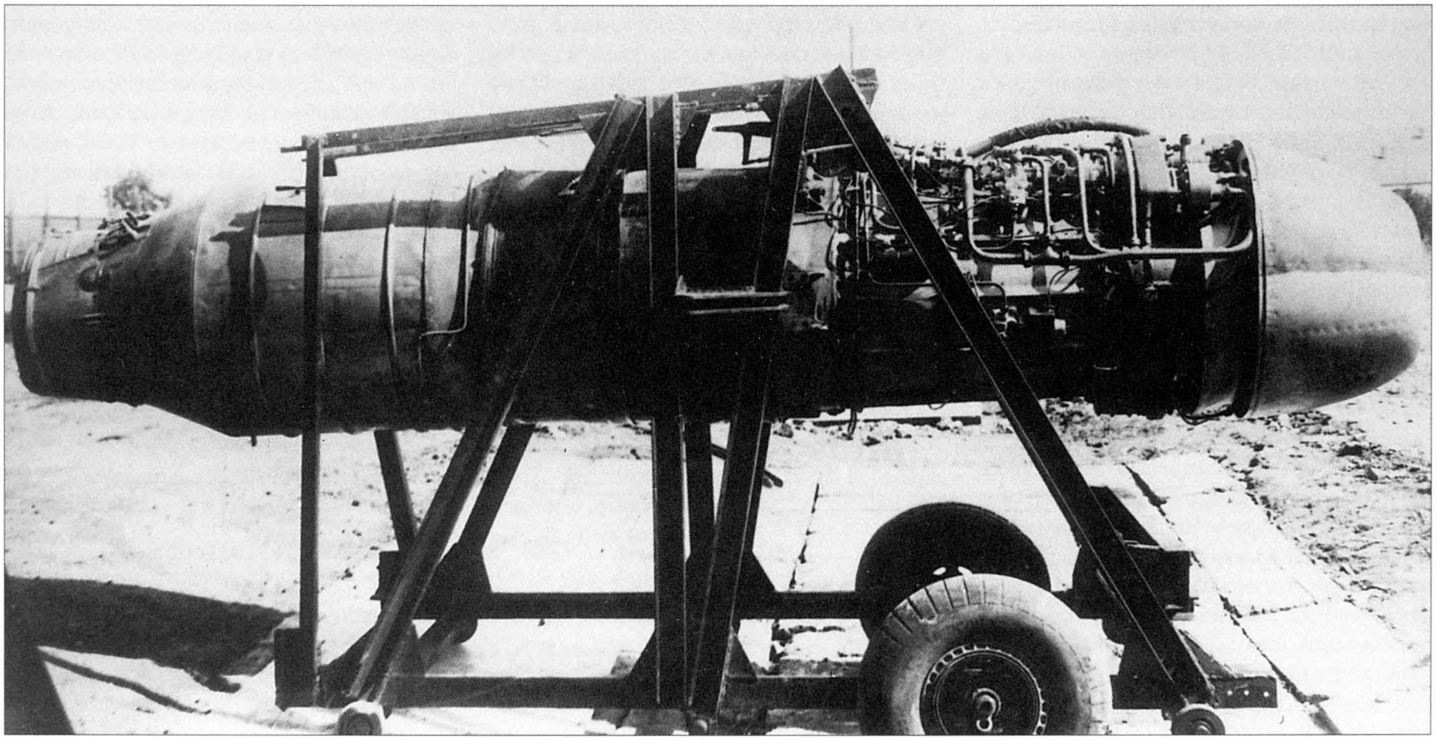
The development of the first Soviet jet aircraft was an arduous process fraught with many difficulties. The following document, which is worth quoting in full, testifies to the problems which the engineers at OKB-134 and TsAGI ran into:

'Attn: Chief Inspector Comrade G. B. Sokolov, Ministry of State Inspection

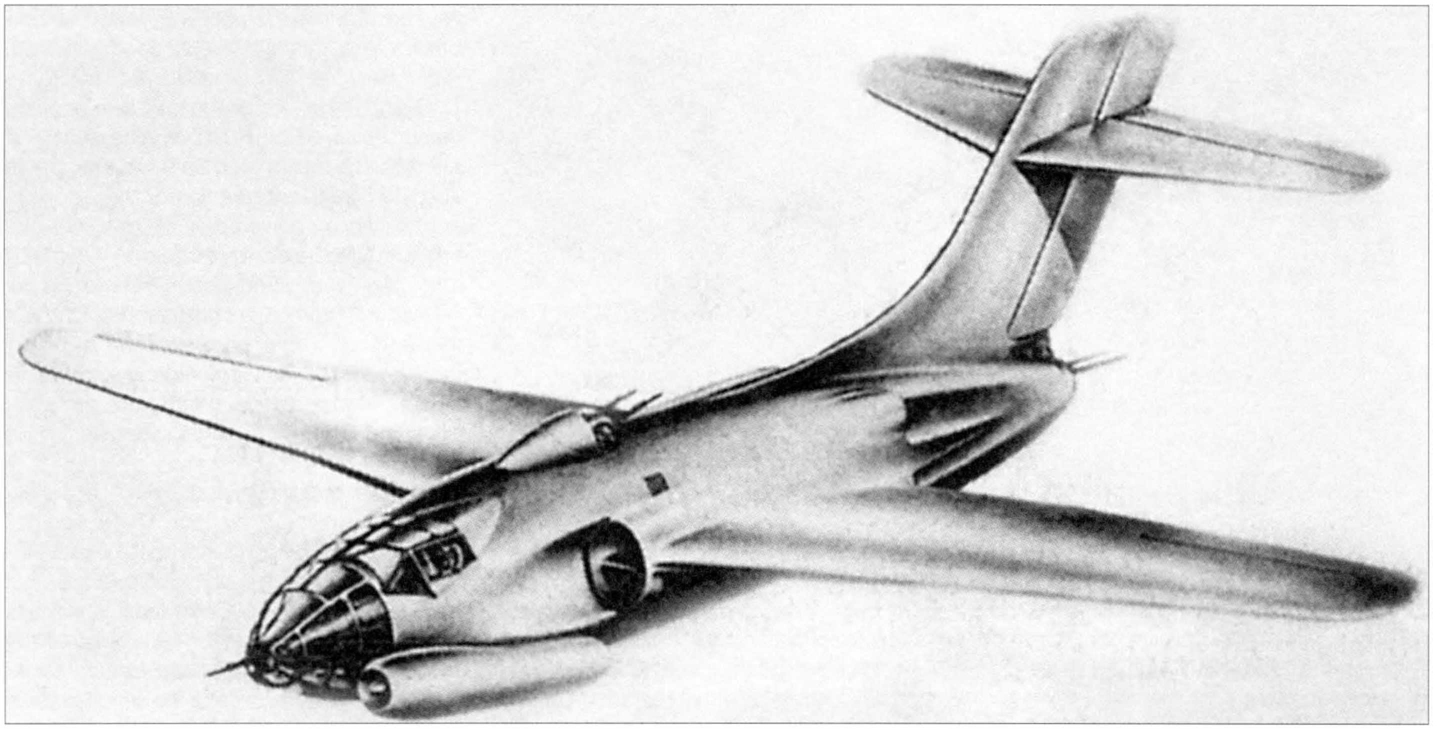
Due to the availability of jet engines enabling aircraft to attain speeds of 800 km/h [500 mph] *and higher the experimental design bureaux within the MAP system are encountering difficulties in selecting the best aerodynamic layout and, first and foremost, the best wing airfoil having a high critical Mach number (ie, 1 and higher).*

TsAGI turned out to be unprepared to extend any significant aid to the experimental design bureaux even as far as the choice of wing airfoils for high-speed aircraft is concerned, to say nothing of new aerodynamic layouts optimised for high-speed flight.

True, TsAGI do not refuse to give advice – at least with regard to high-speed wing airfoils,



The RD-10F afterburning turbojet was envisaged for the four-engined version of the Su-10.



Above: The No.2 project configuration was a real scary monster. Two of the six RD-10 engines were mounted low on the forward fuselage sides and the other four were buried in the fuselage. Note also the parabolic nose with an almost buried cockpit canopy offset to port and the dorsal 'hump' incorporating a glazed 'ball' turret.

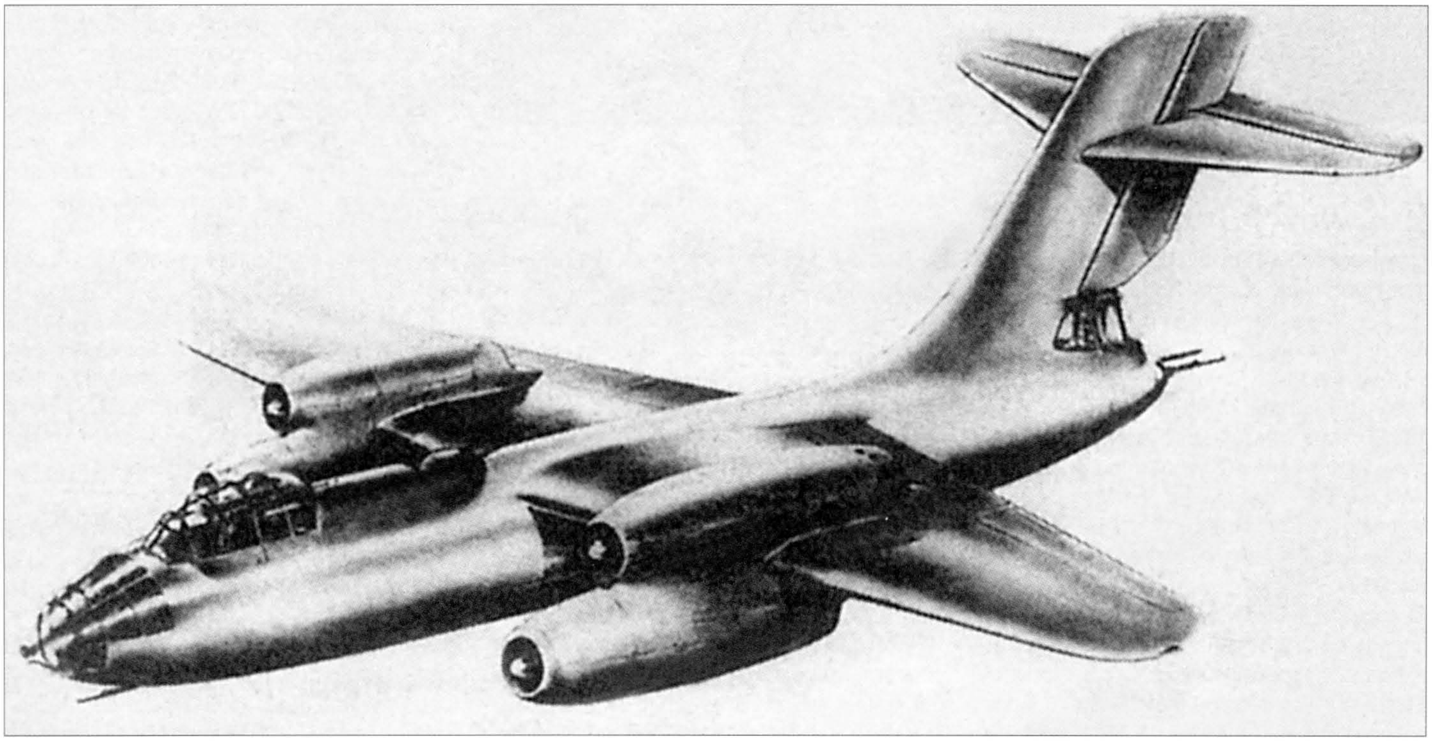
but this advice often turns out to be useless and leads only to delays in the design process and unnecessary expenditures, not to mention the fact that the engineers are never sure whether the recommendations they receive are good.

Since TsAGI do not have a portfolio of high-speed airfoils (ie, a range of verified airfoils), in response to the industry's requests they consistently give recommendations which they subsequently disavow. [...] The work (on the *izdeliye* Ye bomber – *Auth.*) *has reached the advanced development project stage, yet TsAGI have already rejected the 12145 and TS-12 airfoils which they had recommended earlier and are now recommending the Sh-12 and P-2-12 airfoils.*

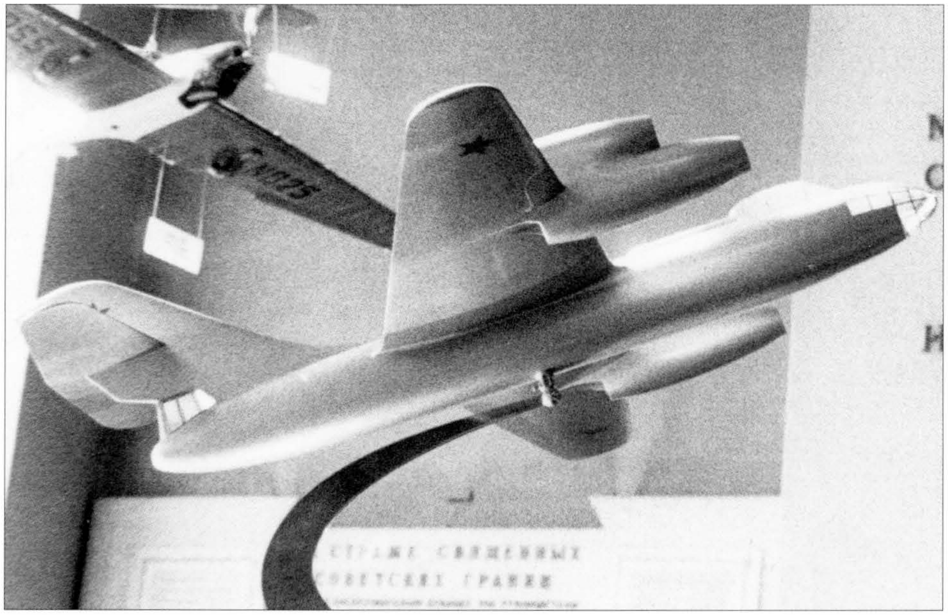
Judging by TsAGI's previous recommendations and by how they theoretically and experimentally substantiate their recommendations, the wing airfoils of aircraft 'Ye' will have to change more than once yet.

Incidentally, all these misguided recommendations concerning airfoils have been with respect to for aircraft designed for speeds below Mach 1; meanwhile, by now TsAGI should have developed and verified airfoils suitable for Mach 1 and higher.

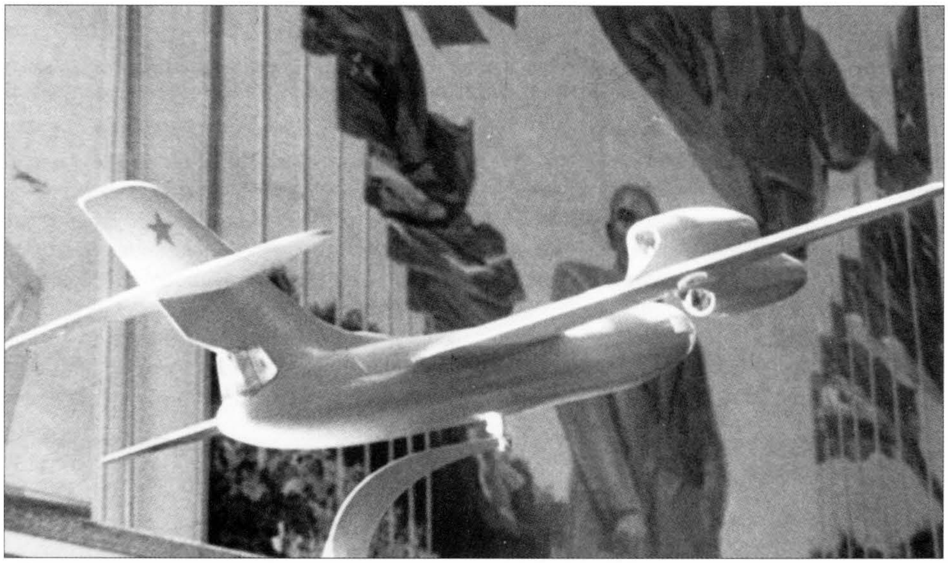
(signed) Plant No.134 Chief Engineer Gorboonov.'



The ultimate configuration with two vertically staggered pairs of TR-1As. The forward fuselage has reverted to its original form, albeit the canopy is slightly different; note the remote-controlled cannon barbette ahead of the wing leading edge.



Above and below: This desktop model of the Su-10 in its ultimate form displayed at the Central Armed Forces Museum in Moscow shows how the rear ends of the engine nacelles are mated with the wing surface.



On 16th August the OKB set to work on the manufacturing drawings for the real thing. On 7th October the completed full-scale display mock-up was unveiled for the preliminary mock-up review commission; throughout the following week changes were incorporated to rectify the faults pointed out by the commission. Also on 14th October the first metal was cut on the airframe of the flying prototype. On 18th October the updated display mock-up was ready for presentation to the State commission; the latter signed its formal acceptance on 2nd December.

Two days later a major change took place: in accordance with a proposal of the State commission (which had sanctioned the change on 3rd December) and with the permission of Vice-Minister of Aircraft Industry Shishkin it was decided that the Su-10 would be powered by four Lyul'ka TR-1 axial-flow turbojets rated at 1,400 kgp (3,090 lbst) for take-off. The change of powerplant was expected to improve the bomber's performance.

The full set of manufacturing drawings was completed on 23rd December. Three days later the OKB's prototype construction shop completed assembly of the static test airframe and began manufacturing the jigs and tooling for the flying prototype.

On 7th January 1947 the ADP of the TR-1 powered version received a thumbs-up from the aircraft industry organisation reviewing it. Two weeks later, on 15th January, the rear spar of the static test article failed at the inboard aileron bracket at 100% of the design load.

The Minister of Aircraft Industry's order concerning the 18th August 1947 air parade during the Aviation Day festivities at Moscow-Tushino airfield illustrates well the 'scalded cat' mode in which the Soviet aircraft industry worked in the early post-war years. Among other things, this remarkable document said, *'Chief Designer and Plant No.134 Director P. O. Sukhoi shall prepare the 'K' twin-engined fighter powered by RD-10 engines* (the first aircraft to be designated Su-9 – *Auth.*) *by 20th July, complete construction of the 'LK' twin-engined fighter powered by TR-1 engines* (the first aircraft to be designated Su-11 – *Auth.*) *by 25th May and flight tests of same by 1st August, and complete construction of the 'Ye' four-engined bomber powered by TR-1 engines by 10th July and flight tests of same by 5th August.'* Three brand-new aircraft at once and within such a tight schedule... have mercy!

In the definitive version of the ADP the aircraft was powered by four TR-1A engines uprated to 1,500 kgp (3,300 lbst) for take-off – the version that the IL-22 was to receive but never did. The engines were located in much the same fashion as on the first version of the project – in staggered vertical pairs, the upper engines exhausting above the wings and the lower engines beneath the wings; the rear ends of the cowlings were smoothly faired to the wing skin. The lower engines 'won by half a length', if we use the analogy with race horses, and were inclined slightly upwards to bring them closer to the upper ones. This feature, which distinguished the Su-10's engine installation from that of the Myasishchev DSB-17, reduced the height and cross-section area of the nacelles. Again, the accessories of the upper and lower engines were located in tandem, which also reduced the distance between the engines' axes in spite of the thick wing airfoil.

The change of powerplant not only increased the aggregate thrust from 5,400 kgp (11,900 lbst) to 6,000 kgp (13,230 lbst) but also saved 1,000 kg (2,205 lb) of empty weight (partly due to the fact that less metal was required for the nacelle structure) and improved the wing aerodynamics, the new nacelles being rather cleaner. On the minus side, access to the upper engines became more complicated.

On 8th March 1947 Sukhoi OKB aerodynamics section chief I. Ye. Baslavskiy presented the estimated performance figures of the *izdeliye* Ye (Su-10) with various powerplant options. Predictably, the TR-1A powered version offered better performance than the RD-10 powered six-engined version for the reasons stated above; the tables below illustrate this point.

The estimated performance of the TR-1A powered Su-10 – specifically, top speed at the specified altitude (850 km/h; 528 mph) and take-off weight with a 4-ton (8,820-lb) bomb load – met the day's standards quite well. The performance would be even better with more powerful engines (the Lyul'ka OKB intended

The Su-10's performance with 6 x RD-10

All-up weight, kg (lb)	Bomb load, kg (lb)	Fuel load, kg (lb)	Altitude, m (ft)	Speed, km/h (mph)	Range, km (miles)
19,500 (42,990)	1,000 (2,205)	5,700 (12,570)	10,000 (32,810)	655-690 (406-428)	1,500 (930)
21,700 (47,840)	1,000 (2,205)	7,760 (17,110)	10,000 (32,810)	660-700 (410-434)	2,000 (1,240)
21,700 (47,840)	4,500 (9,920)	4,400 (9,700)	10,000 (32,810)	650-710 (403-441)	1,020 (633)

The Su-10's performance with 4 x TR-1

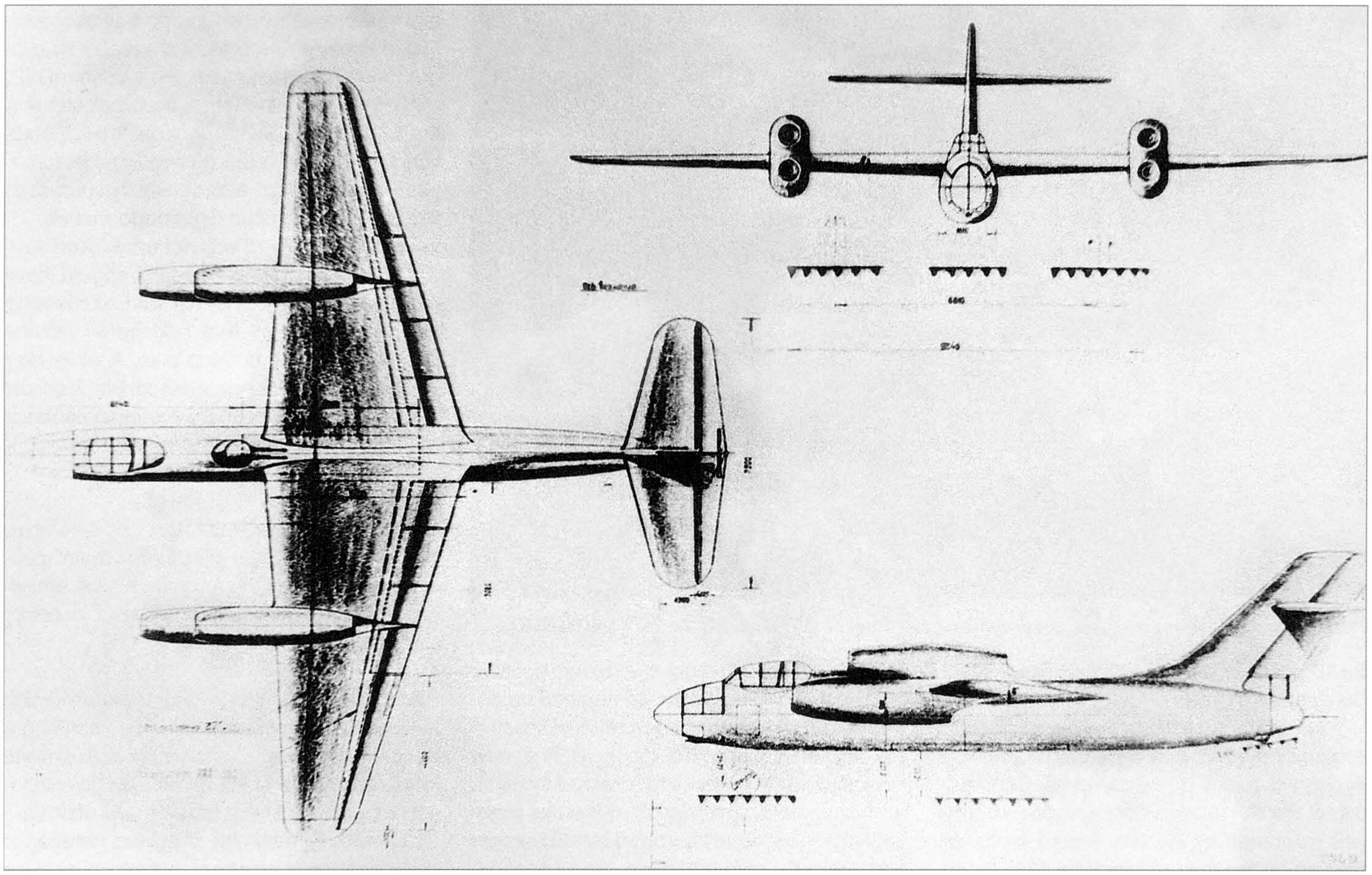
All-up weight, kg (lb)	Bomb load, kg (lb)	Fuel load, kg (lb)	Altitude, m (ft)	Speed, km/h (mph)	Range, km (miles)
18,950 (41,780)	1,000 (2,205)	5,300 (11,690)	10,000 (32,810)	700 (434)	1,500 (930)
21,230 (46,800)	1,000 (2,205)	7,500 (16,530)	10,000 (32,810)	700 (434)	2,000 (1,240)
21,230 (46,800)	2,000 (4,410)	6,500 (14,330)	10,000 (32,810)	700 (434)	1,700 (1,055)
21,300 (46,960)	3,000 (6,610)	5,580 (12,300)	10,000 (32,810)	700 (434)	1,400 (870)
21,230 (46,800)	4,000 (8,820)	4,580 (10,100)	10,000 (32,810)	700 (434)	1,100 (680)

to uprate the TR-1A to 2,000-2,500 kgp [4,410-5,510 lbst] in due course).

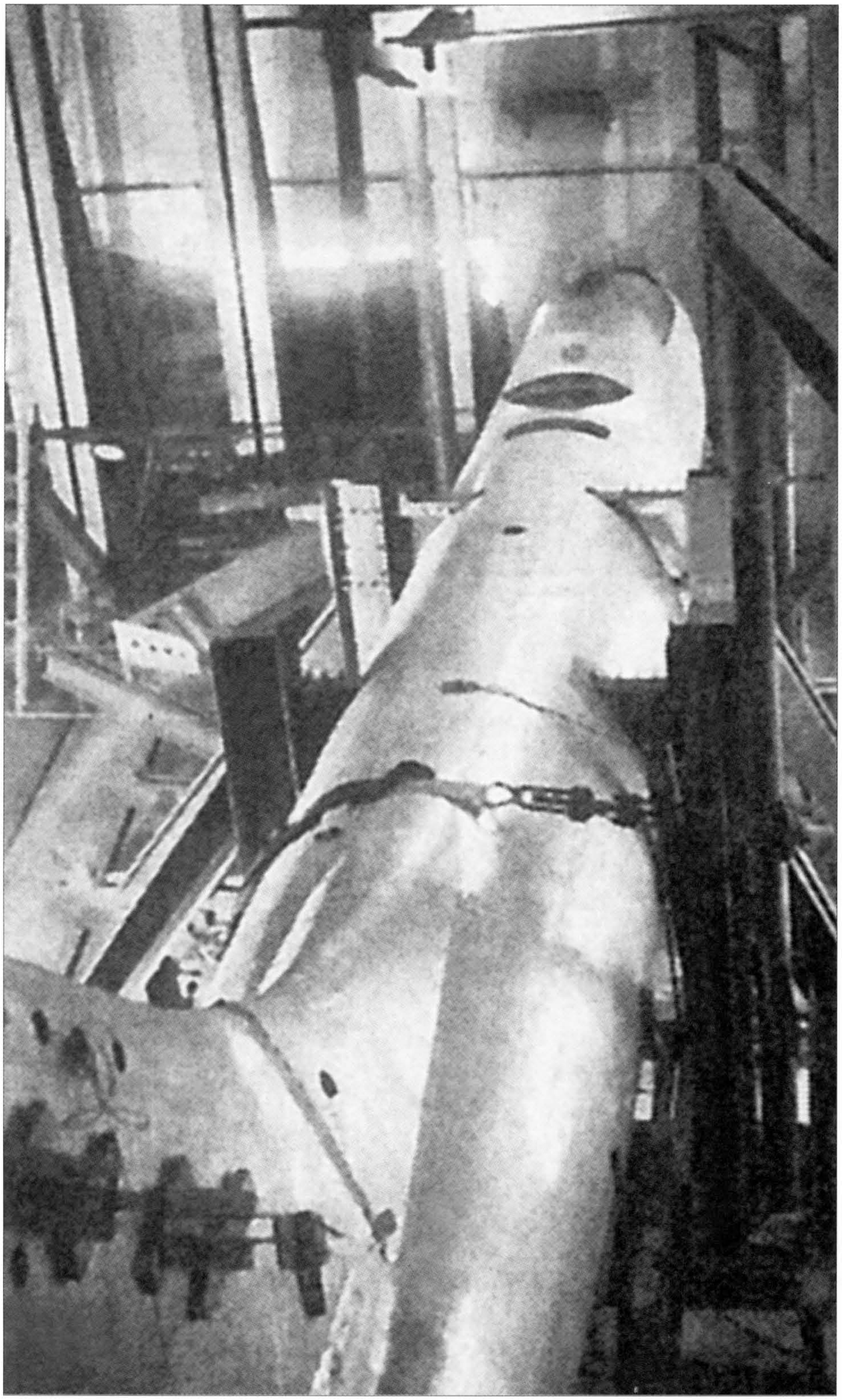
The propulsion section of OKB-134 ran into problems when developing the Su-10's definitive powerplant; new and hitherto untried fuel feed and engine starting systems had to be developed. The difficulties were due to the fairly large size of the aircraft and the large amount of fuel required for the four turbojets; the position of the fuel tanks and their emptying sequence had to be chosen in such a way as to keep the aircraft's CG within acceptable limits. To this end it was envisaged that fuel would be transferred between the forward and aft tanks as appropriate to maintain CG position.

On 11th March 1947 the Council of Ministers issued yet another directive calling for the development and construction of a medium bomber powered by four TR-1A turbojets with a take-off rating of 1,500 kgp instead of the bomber powered by four Jumo 004Bs which was envisioned by the aforementioned directive of 26th February 1946. The appropriate MAP order followed on 16th April; thus the re-engined version of the Su-10 (*izdeliye* Ye) was fully legalised.

Static tests of the Su-10's fuselage began on 21st April. On 19th August Chief Designer Pavel O. Sukhoi wrote to the Director of TsAGI, requesting that the appropriate section of the institute be tasked with developing the wings for a prospective version of the



A three-view drawing of the Su-10 in ultimate configuration from the project documents; note the strong forward sweep on the wing trailing edge.



The static test airframe of the Su-10 under construction. Note the circular cutout for the dorsal barbette.

Su-10 powered by four RD-500 (Rolls-Royce Derwent V) turbojets.

On 15th December the bomber's hydraulic system was assembled and put through its paces on a ground rig. Construction of the Su-10 in its definitive project form was hampered by the very limited prototype production facilities at plant No.134; manufacture of the jet bomber prototype's airframe subassemblies could not commence until the prototype of the Su-12 piston-engined reconnaissance/artillery spotter aircraft had vacated the assembly shop. To top it all, the new bomber was to feature a lot of novel systems and equipment, which led to numerous problems that needed to be solved by experiment and scientific research. Prototype construction was also slowed considerably by the numerous subcontractors which were late in delivering various equipment items. Thus the defensive armament (developed by the Ministry of Defence Industry's OKB-43), the AP-5 autopilot, the ARK-4 automatic direction finder and even the TR-1A engines were all scheduled for delivery in 1947 but OKB-134 received none of these items that year.

Meanwhile, the OKB continued exploring alternative powerplants for the Su-10. On 12th March 1948 it completed a stage of a design programme aimed at powering the bomber with four Lyul'ka TR-2 axial-flow turbojets; the intention was to conduct initial flight tests with TR-1As, replacing them with TR-2s when these became available. State acceptance trials were slated to commence four months after the Su-10's first flight with the latter powerplant. During bench tests the TR-2 prototype showed a static thrust of 1,885 kgp (4,155 lbst), which was 385 kgp (850 lbst) higher than that of the TR-1A and 485 kgp (1,070 lbst) higher than that of the TR-1 *sans suffixe*.

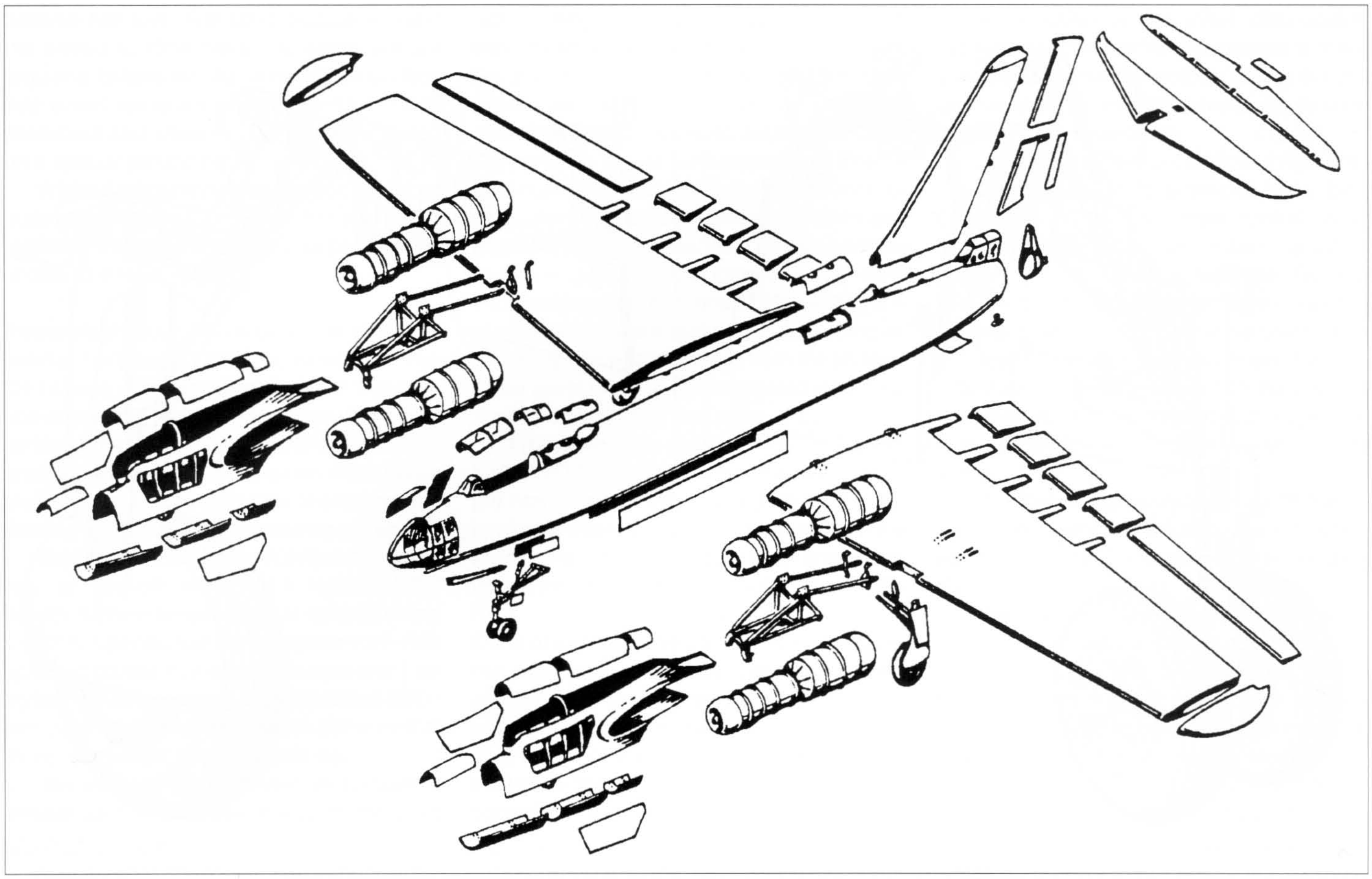
Still, the Su-10 was robbed of its chance to fly. On 4th June 1948 the Council of Ministers issued a directive titled 'On the reduction of R&D (research and development) expenditures for the aviation industry in 1948'; this was followed eight days later by another directive setting out the plan of MAP's R&D activities for 1948 and terminating all programmes for which no funding was allocated. The unlucky ones included the Su-10 programme. That same year the Il'yushin OKB, putting all the experience accumulated with the IL-28 prototype, brought out the IL-28 tactical bomber powered by two RD-45F turbojets – an excellent aircraft which surpassed the Su-10's estimated flight performance.

Hence the Su-10 was not even rolled out – which was a shame; it really should have been test-flown – just for the sake of checking that the know-how that had gone into the design worked, if nothing else. A while later the prototype was donated to the Moscow Aviation Institute as an instructional airframe.

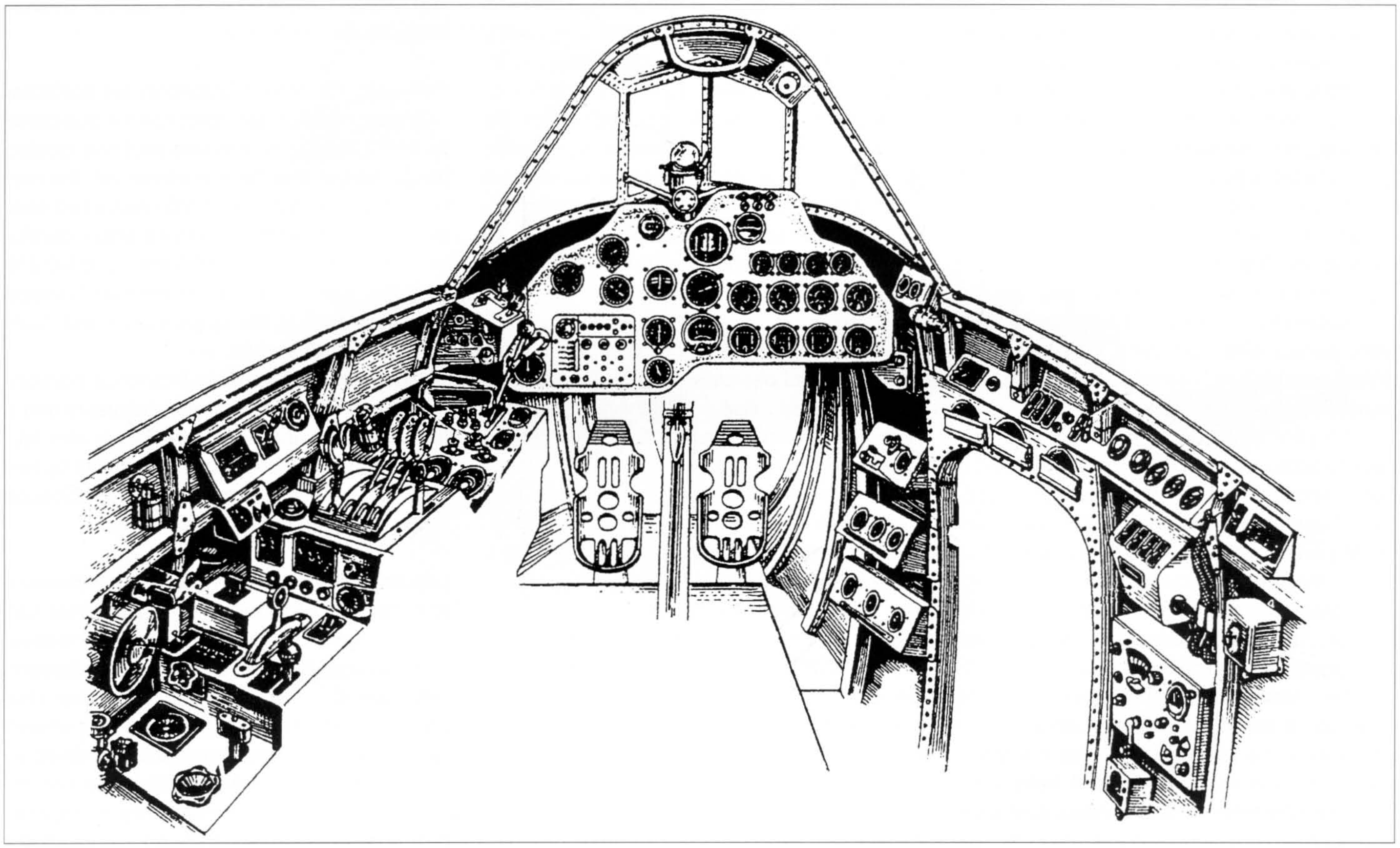
The following is a brief structural description of the Su-10.

Type: Four-engined four-seat tactical bomber. The airframe was of riveted all-metal construction. The crew comprised a pilot, a navigator/bomb-aimer, a gunner/radio operator and a tail gunner/observer.

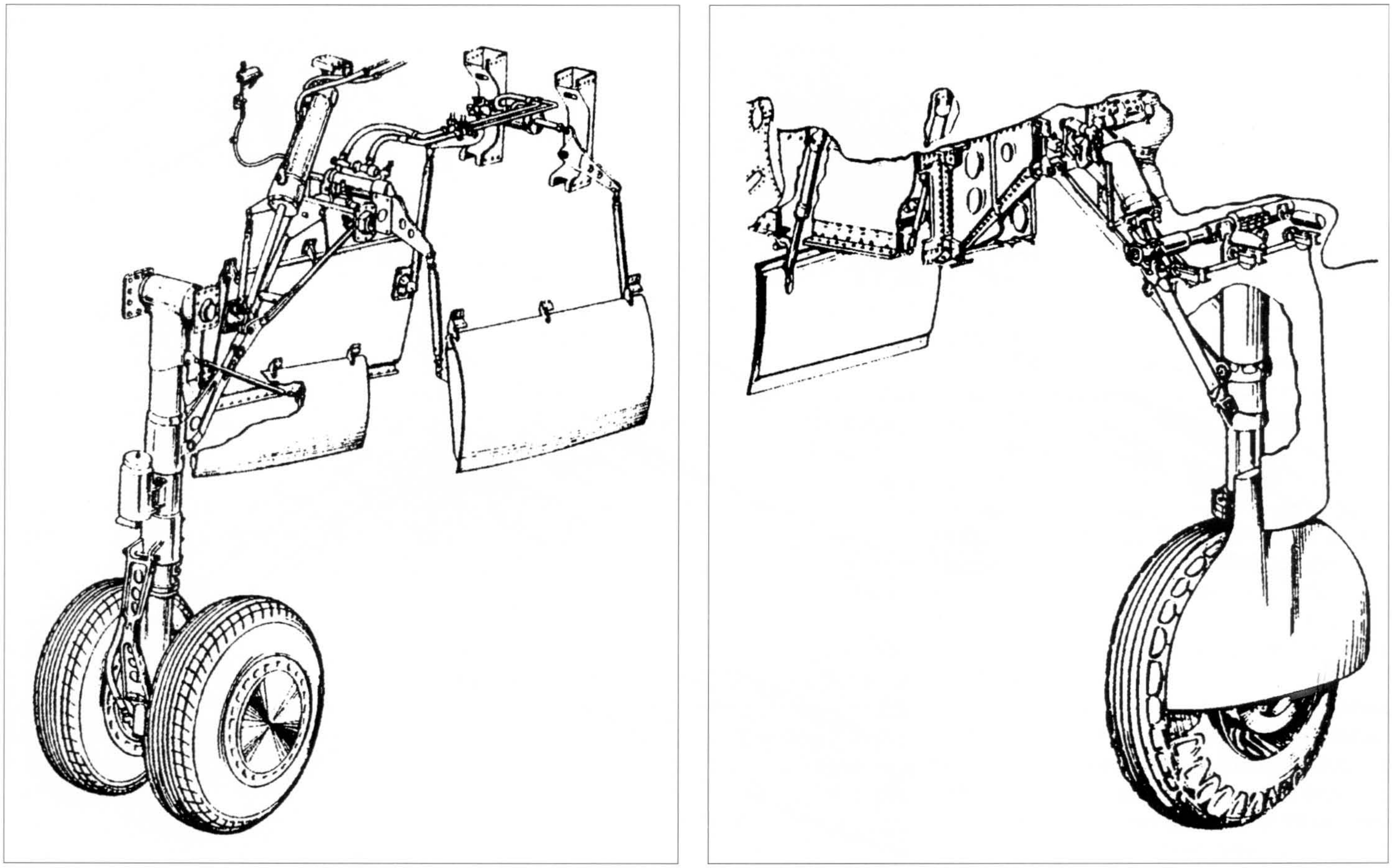
Fuselage: Semi-monocoque stressed-skin structure of circular cross-section featuring a beam-and-stringer construction with several longerons made of sheet metal and variable-section profiles. The skin was made of D16A-T duralumin; to minimise drag the number of skin panel joints was kept to a minimum. Skin thickness was 1.5-2.5 mm (0.059-0.098 in) on



Above: An exploded view of the Su-10 in its ultimate configuration. Note the four-section flaps and the engine bearer/nacelle design.



The cockpit of the Su-10.



These drawings from the advanced development project documents illustrate the design of the nose and main landing gear units.

the centre fuselage and 1.0-1.2 mm (0.039-0.047 in) on the forward and rear fuselage.

Structurally the fuselage consisted of three sections: forward, centre and rear.

The *forward fuselage* incorporated the forward pressurised cockpit accommodating the pilot, the navigator/bomb-aimer and the gunner/radio operator who were provided with ejection seats. Access was via a door to starboard, which could be jettisoned in an emergency. The navigator/bomb-aimer sat in the extreme nose; his extensively glazed workstation featured a bombsight and instrument panels with navigation instruments. A dorsal escape hatch offset to starboard was provided in the navigator's station roof.

The pilot and gunner/radio operator sat back to back under a common canopy with a fixed windscreen and two jettisonable sections. Prior to ejection the pilot's seat was tilted 18° to port by a spring-loaded mechanism to ensure that he was thrown clear of the tail unit. The forward cockpit was protected by steel armour. The unpressurised nosewheel well was located under the cockpit floor.

The *centre fuselage* incorporated the large bomb bay closed by twin doors, aft of which were the rear fuel tank and the brake parachute container further aft. A hefty truss with cross-members made of chromium steel was located above the bomb bay; it was mated to the wing spars.

The *rear fuselage* incorporated the fin attachment fittings and accommodated the pressurised tail gunner/observer's compartment. The latter featured a gunsight and an automatically elevating seat with a hydraulic drive which adjusted it, depending on the angle of the cannon; the gunner was protected by steel armour and extensive bulletproof glazing. The tail gun barbette was attached by four explosive bolts and could be jettisoned in an emergency, allowing the tail gunner/observer to bail out.

Wings: Cantilever shoulder-mounted monoplane wings of basically trapezoidal planform with rounded tips. Slight leading-edge sweepback and more pronounced forward sweep on trailing edges, both constant from roots. The wings were one-piece two-spar stressed-skin structures utilising TsAGI Sh-2-12 airfoils at the roots and SR-3-12 airfoils at the tips optimised for high subsonic speeds. The I-section spars had variable-thickness duralumin webs and composite caps made of 30KhGSA steel strips and duralumin angle pieces; they were attached to the fuselage mainframes. The stringers were made of extruded beaded angle pieces.

The engine nacelles were attached to the wings approximately at half-span; their design was optimised for minimum interference drag. The wings were equipped with four-section trailing-edge flaps and two-section ailerons; the port inboard aileron section incorporated a trim tab.

Tail unit: Cantilever cruciform tail surfaces. The swept vertical tail comprised a one-piece fin and a rudder built in two sections located above and below the horizontal tail; the rudder featured a trim tab. The fin was a two-spar stressed-skin structure with 16 sheet duralumin ribs and a skin 0.8 to 2.0 mm (0.031-0.078 in) thick; it was attached to the rear fuselage by several fittings, the spars mating with fuselage frames 43 and 51.

The unswept variable-incidence horizontal tail comprised one-piece stabilisers and a one-piece full-span elevator with a trim tab. The stabilisers were attached to the fin by two hinges located on the front spar; incidence was adjusted electromechanically.

Landing gear: Electrohydraulically retractable tricycle type. All three landing gear struts had oleo-pneumatic shock absorbers; all wheels were equipped with brakes. The aft-retracting nose unit was equipped with a breaker strut and twin 660 x 160 mm (25.98 x 6.3 in) wheels and an internally mounted shimmy damper.

The main units retracted inwards into the wing roots; each unit had a forward-mounted drag brace, a breaker strut and a single 700 x 250 mm (27.55 x 9.84 in) wheel carried on an external half-fork. The latter feature allowed the wheels to stow inside the wings without requiring bulges on the wing upper surface that would generate extra drag. The shock absorbers and shimmy damper were tested on a special ground rig.

A faired tail bumper with a shock absorber protected the rear fuselage in the event of a tailstrike. A brake parachute was provided to shorten the landing run.

Powerplant: Four TR-1A axial-flow turbojets rated at 1,500 kgp (3,300 lbst) for take-off. The TR-1A was a single-spool turbojet featuring non-adjustable air intake assembly with outer fairing and central spike, an eight-stage compressor, an annular combustion chamber, a single-stage turbine and a fixed-area nozzle. Starting was by means of a starter-generator.

Engine pressure ratio (EPR) 3.16, mass flow at take-off rating 31.5 kg/sec (69.4 lb/sec), turbine temperature at take-off rating 1,050° K. Specific fuel consumption 1.27-1.35 kg/kgp·h (lb/lbst·h) in full afterburner and 1.29 kg/kgp·h in cruise mode. Length overall 3,860 mm (12 ft 8 in), casing diameter 856 mm (2 ft 9¾ in), dry weight 856 kg (1,886 lb).

The engines were housed in staggered vertical pairs in nacelles ahead of the wing leading edge, the upper and lower engine exhausting above and below the wing respectively, and carried on truss-type bearers. Each nacelle was formed by the engines' air intake assembly fairings, multiple detachable cowling panels and rear fairings made of EYa 1T heat-resistant steel; cooling air captured by air scoops was forced between the inner and outer skins of these fairings. The rear portions of the engines (inside the cowlings) were enclosed by shrouds made of the same grade of steel which were quite difficult to remove. The wing skin was protected from the jet blast of the lower engines by corrugated steel heat shields adhering to the wing undersurface.

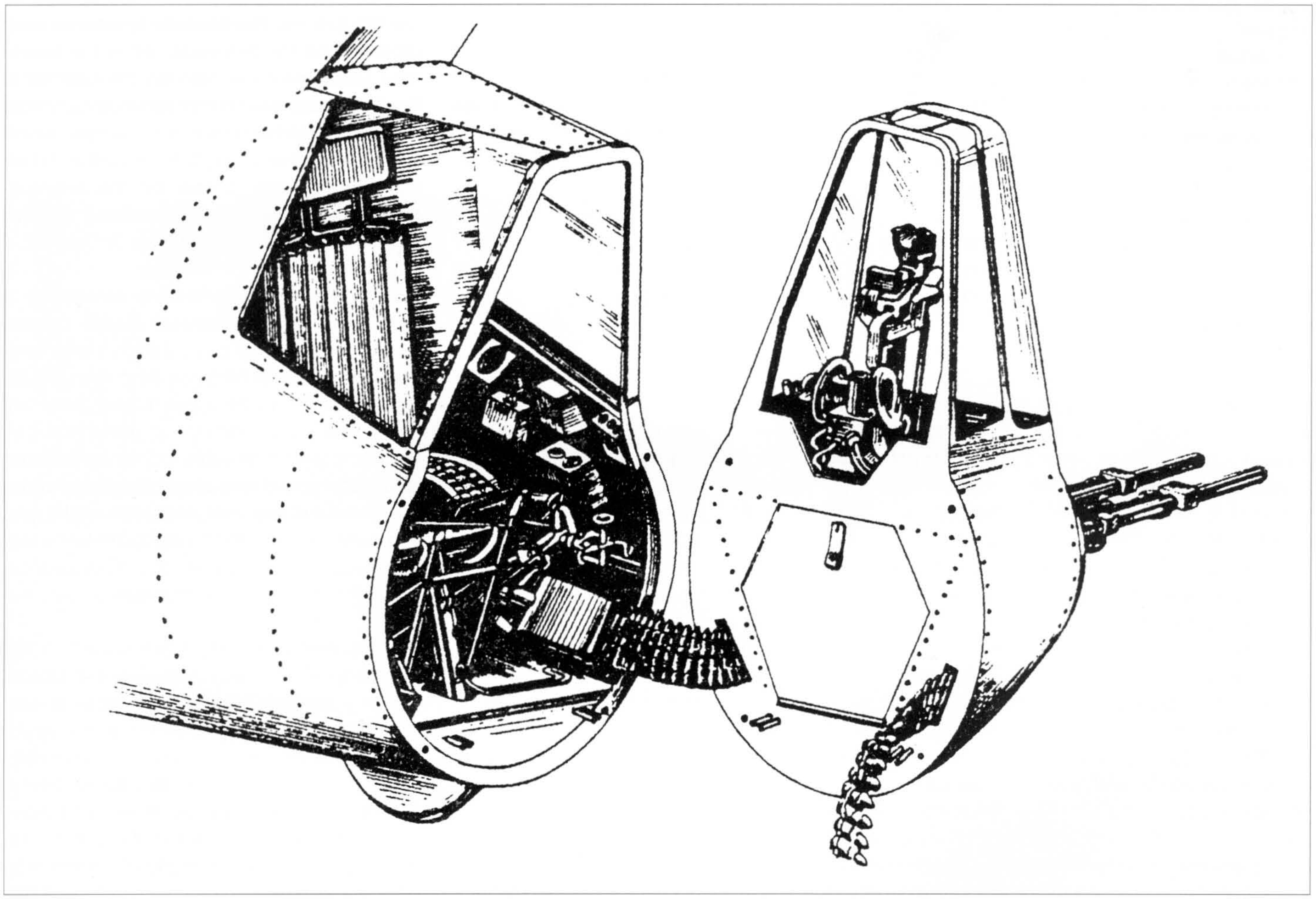
Provisions were made for four U-5 solid-fuel JATO boosters which were attached to the rear fuselage sides and jettisoned automatically after burnout or manually in the event of failure. The U-5 had been tested earlier on the Su-9 (*izdeliye* K) fighter prototype.

Control system: The Su-10's control system had a few peculiarities due both to the general arrangement and airframe design features and to the aircraft's mission. The considerable length of the control runs and the high control forces dictated the need for powered controls throughout with irreversible hydraulic actuators. Other factors influencing control system design were the requirement to make automatic course corrections during the target run and the necessity to ensure safe crew ejection in an emergency.

The elevator control circuit had rigid linkage throughout, with push-pull rods, bellcranks and levers. The rudder control circuit featured mostly cables and rollers, rigid linkage being used in the rear fuselage only. The elevator and rudder actuators were housed in the rear fuselage, as close to the control surfaces as possible in order to apply the considerable forces they created to the shortest possible stretch of the control runs; the aileron actuators were accommodated in the wings.

The control system included an AP-5 electric autopilot which is linked to the S-1 bombsight to provide accurate course holding during the bombing run.

The control column was of the usual bomber type, with a chain transmitting the motion of the wheel to the cables of the aileron control circuit. It was located a bit too close to the seat, so a special safety mechanism retracted it automatically before ejection, moving the control column all the way forward to prevent injuries to the pilot.



This drawing from the advanced development project documents shows how the rear wall of the tail gunner's station swung open together with the tail barbette to permit gunner entry/egress; it was jettisoned in an emergency for bailing out. Note the ammunition belts.

The cast metal rudder pedals with a horizontal axle also worked the wheel brakes by means of a hydraulic brake control valve.

Electrics: Main electric power provided by four 3-kW engine-driven DC generators; backup DC power provided by a storage battery. Electric equipment included the motors of the dorsal and rear cannon barbettes, the autopilot, the trim tab actuators, fuel transfer pumps, communications equipment and internal/external lighting. To facilitate single-pilot operation of a four-engined aircraft the cockpit featured numerous packet (combined) switches in the engine control system.

Hydraulics: The hydraulics operated on a preferential basis, serving the landing gear, flaps, tail cannon barbette and bomb bay doors, in that order. Three separate hydraulic systems; the No.1 system powered by two pumps on the port lower engine operated the landing gear, flaps and wheel brakes. The No.2 system powered by a pump on the starboard lower engine operated the stabiliser trim mechanism, the bomb bay doors and the tail barbette. The No.3 system powered by another pump on the same engine operated the aileron, rudder and elevator actuators. Dual hydraulic valves and a hydraulic accumulator were provided.

Oxygen system: The oxygen equipment included breathing apparatus for the four crew members and several gaseous oxygen bottles.

Avionics and equipment: The avionics suite included an RSB-3*bis* communications radio, an RSI-6 command link radio, an intercom, an ARK-4 ADF, an RV-2 radio altimeter with dipole aerials under the aft fuselage etc. An AFA-33 camera on a tilting mount was provided for ordinary and post-strike reconnaissance; the camera bay doors were remote-controlled by a UR-2 mechanism. Most of the communications equipment and other equipment controls were located at the gunner/radio operator's station.

The pilot's instrument panel was a one-piece full-width unit accommodating the flight instrumentation and the engine control instruments and switches. It was attached to the structure in several places by vibration dampers; the upper centre portion was connected to the dampers via connecting rods.

Armament: The Su-10 had a sizeable bomb load, all of which was carried internally. Possible *offensive weapon* loads included a single 3,000-kg (6,610-lb) FAB-3000 M-46 high-explosive bomb, or twelve 250-kg (551-lb) FAB-250 M-46 bombs, or twenty 100-kg (220-lb) FAB-100s. The bomb bay was equipped with four KD-3 three-shackle cassette-type bomb racks (kassetnyy derzhahtel'), or four KD-2 three-shackle racks, or a BD-4 beam-type rack (bahlochnyy derzhahtel') for FAB-3000 and FAB-1500 bombs, or two BD-2 racks. The cassette-type racks were mounted on the sidewalls, while the beam-type racks were installed on the centreline. Bomb release was controlled electrically from the navigator/bomb-aimer's station which was provided with an OPB-1R optical bomb sight (*op**tich**eskiy pri**tsel** bombardi**rov**ochnyy*). Bomb loading was assisted by two BL3-46E electric bomb hoists or two BL-4 hand-driven hoists.

The *defensive armament* comprised a fixed forward-firing Berezin B-20E cannon under the navigator's station floor, a remote-controlled dorsal barbette with two B-20Es located between the bomb bay and the fuel tanks, and a KG-2 remote-controlled tail barbette with two more B-20Es. The nose cannon was fired by the pilot, using a trigger button on the control wheel and a PBP-1B sight, and triggered electrically; the cannon was accessed from outside for maintenance, while the ammunition box was accessible from the navigator's station.

The dorsal barbette was aimed by the gunner/radio operator, using a B-4 optical sighting station. Maintenance access was from above and from below (via the bomb bay); the ammunition boxes were raised into position by a special hoist. The electrohydraulically powered tail barbette had a maximum elevation of 30°, a maximum depression of 45° and a traversing angle of ±30°. It was jettisonable to allow the tail gunner/observer to bail out.

Su-10 specifications (estimated)

	As of 27-8-1946	As of 8-1-1947
Powerplant	6 x RD-10	4 x Lyul'ka TR-1*
Engine thrust, kgp (lbst):		
take-off	6 x 900 (1,980)	4 x 1,400 (3,090)*
cruise (at 800 km/h; mph)	6 x 435 (960)	4 x 677 (1,490)
Engine weight (single), kg (lb)	750 (1,650)	865 (1,910)
Length overall	18.3 m (60 ft 0½ in)	19.06 m (62 ft 6⅜ in)
Height on ground	6.3 m (20 ft 8 in)	6.56 m (21 ft 6¼ in)
Wing span	20.6 m (67 ft 7 in)	20.6 m (67 ft 7 in)
Tailplane span	7.45 m (24 ft 5⅜ in)	7.3 m (24 ft 0½ in)
Wing area, m^2 (sq ft)	70.0 (752.6)	71.3 (766.6)
Vertical tail area, m^2 (sq ft)	10.7 (115.0)	10.6 (114.0)
Horizontal tail area, m^2 (sq ft)	16.3 (175.2)	14.2 (152.6)
Vertical tail airfoil	1V-00	n.a.
Horizontal tail airfoil	1V-00	n.a.
All-up weight, kg (lb):		
normal	19,500 (42,990)	18,950 (41,780)
maximum	21,700 (47,840)	21,230 (46,800)
Empty weight, kg (lb)	11,671 (25,730)	11,300 (24,910)
Payload, kg (lb):		
normal	7,829 (17,260)†	7,650 (16,865)
maximum	10,029 (22,110)†	9,850 (21,715)
Fuel load, kg (lb):		
normal	5,700 (12,570)†	5,300 (11,680)
maximum	7,760 (17,110)†	7,500 (16,530)
Top speed, km/h (mph):		
at sea level	810 (503)	810 (503)
at 6,000 m (19,685 ft)	850 (528)	850 (528)
at 10,000 m (32,810 ft)	830 (515)	825 (512)
Landing speed, km/h (mph)	150 (93)	150 (93)
Climb time to 5,000 m, minutes:		
to 6,000 m	8.3	6.7 (to 5,000 m/16,400 ft)
to 10,000 m	20.4	20.4
Altitude over the target, m (ft)	8,000 (26,250)	8,000 (26,250)
Service ceiling, m (ft)	11,700 (38,385)†	12,000 (39,370)
Take-off run, m (ft):		
without JATO boosters	1,020 (3,364)	1,020 (3,364)
with JATO boosters	600 (1,970)	600 (1,970)

* The Experimental Aircraft Construction Plan for 1946-47 specified four TR-1As rated at 1,500 kgp (3,300 lbst).

† According to the Experimental Aircraft Construction Plan for 1946-47 the service ceiling was to be 12,500 m (41,000 ft), the normal bomb load 1,000 kg (2,205 lb) and the maximum bomb load 4,000 kg (8,820 lb).

Chapter 4

The Junkers Heritage

The Forward-Swept Wing Designs

EF-131 bomber prototype

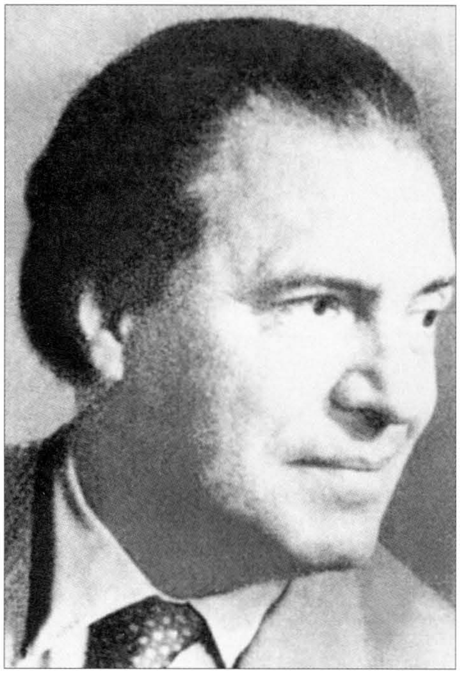
The work on the Junkers EF 131 bomber was initiated in Germany in 1945, but the official commencement of design work may well be dated 17th April 1946 when, in accordance with the Soviet Council of Ministers' directive No.874-266 Chief Designer Brunolf W. Baade was tasked with completing development of the EF 131 bomber and submitting it for tests.

Designated EF-131 V1, the first prototype manufactured in Germany underwent a brief flight test programme there before being dismantled and transported to the Soviet Union. Owing to a protracted preparatory stage that took place in 1946, and to the transfer of the aircraft to the State Experimental Plant No.1 (GOZ – *Gosoo**dar**stvenny **op**ytnyy za**vod***) in Dobna near Moscow, design and development work did not resume before the spring of 1947. Fritz Freitag was appointed Baade's deputy, while Hans Wolf became the project engineer. On 15th April 1947 MAP issued an order requiring GOZ No.1 to conduct the flight testing of the bomber before the end of July. It was envisaged that the EF 131 would take part in the annual Aviation Day Flypast at Moscow-Tushino along with other new Soviet jet aircraft. A testimony to this is the following MAP directive addressed to Vice-Minister Lukin, GOZ No.1 Director Abramov and Chief Designer Baade: *'Prepare two prototype EF 131 bombers powered by six RD-10 gas-turbine engines [...] for participation [...] in the flypast; flight testing of these aircraft shall be completed by 30th July.'*

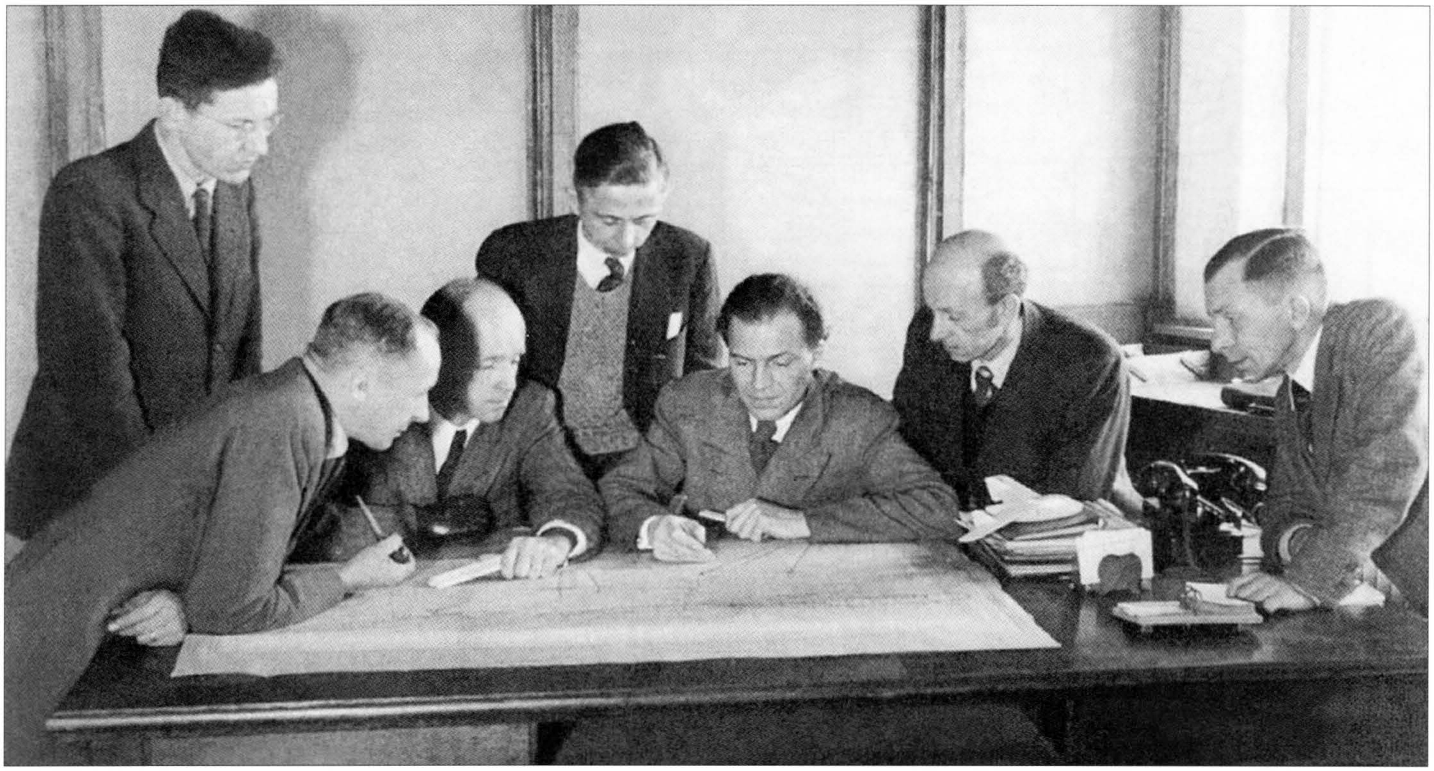
The beginning of the EF-131 bomber prototype's flight tests was postponed because static tests conducted by TsAGI revealed insufficient structural strength of the fuselage. The TsAGI report stated: *'The fuselage meets only 52% of strength standards and possesses sufficient strength only if the speed is limited to 600 km/h'* (373 mph).

Nearly two months were spent on reinforcing the airframe of the first flyable EF-131 which was delivered to LII in the autumn of 1946. Concurrently, Plant No.1 was engaged in the assembly of the second flying prototype which was completed by the end of the year.

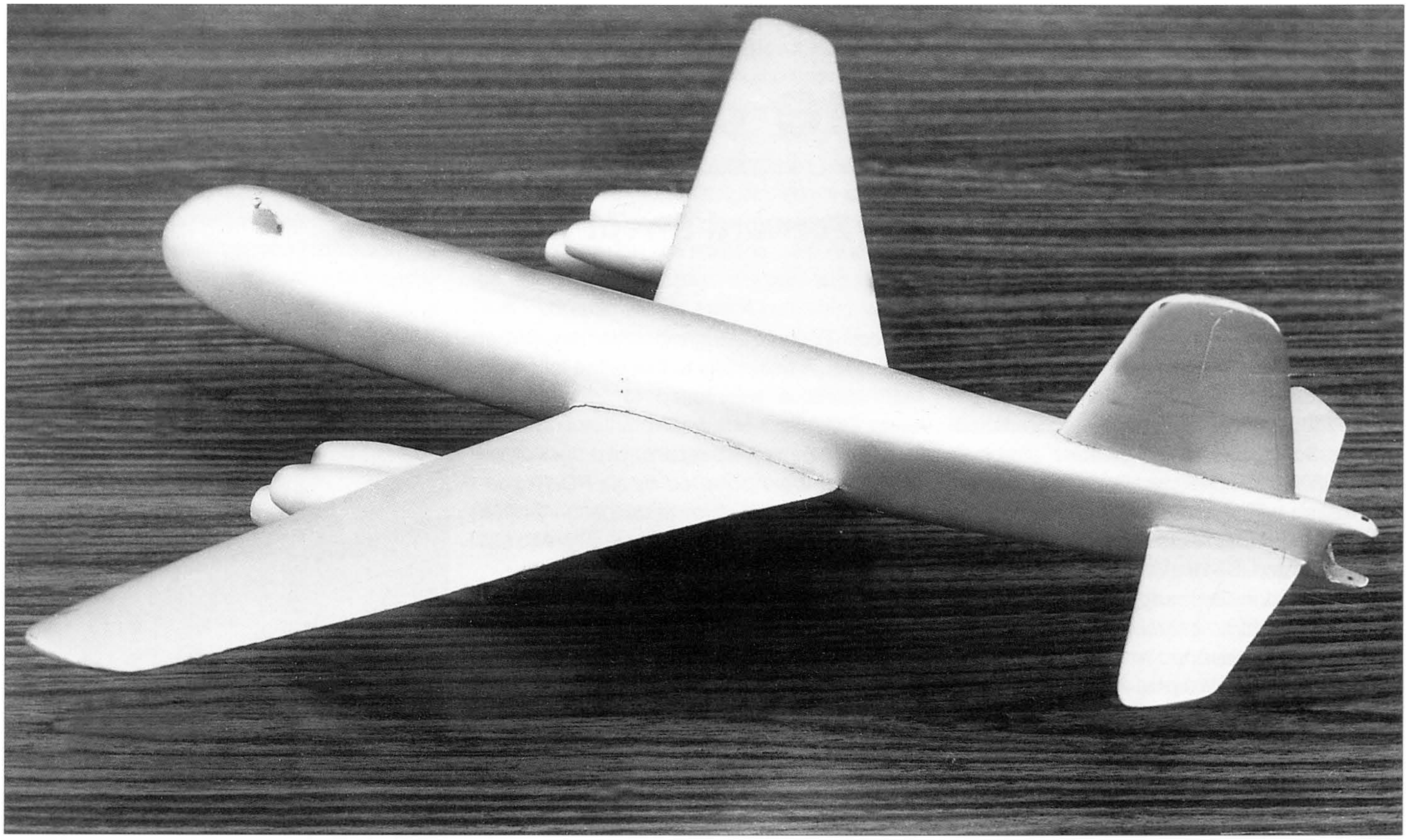
The first flight of the modified EF-131 took place on 23rd May 1947. There is a document



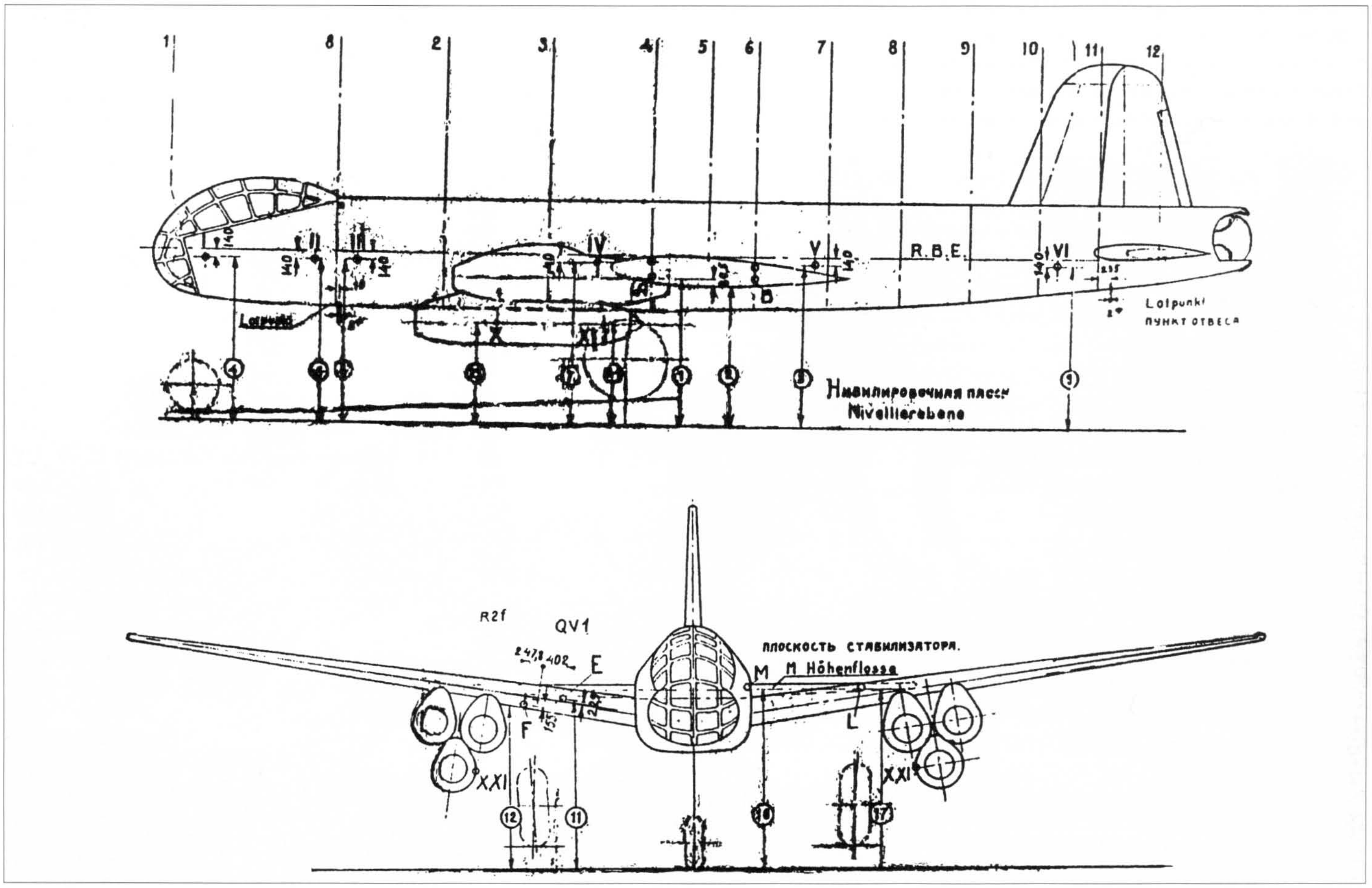
Above: Brunolf W. Baade, head of the German design team at OKB-1.



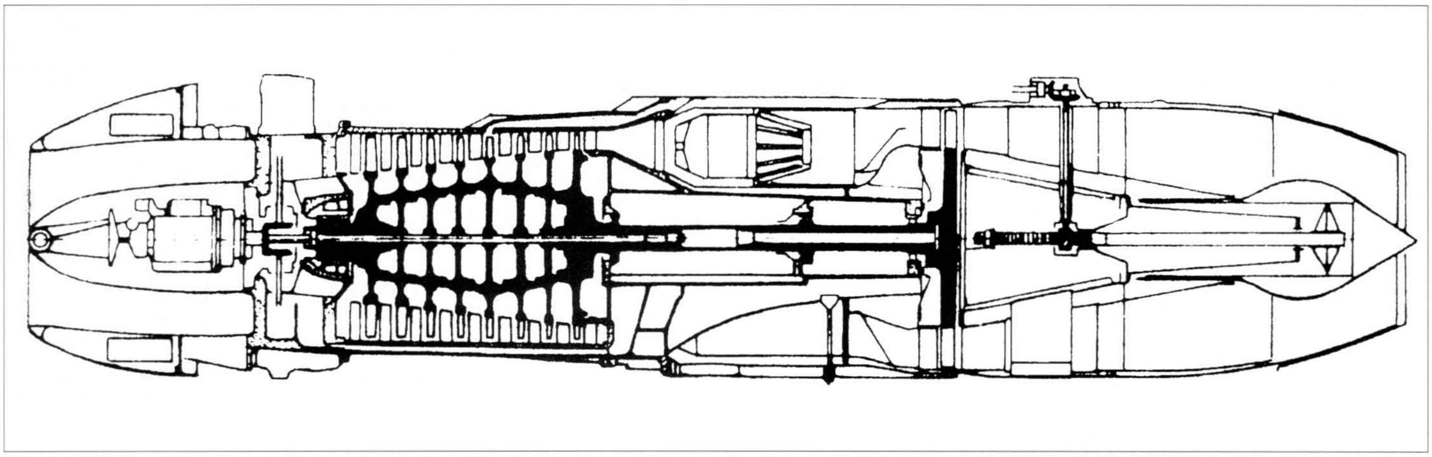
A working conference in Baade's office; left to right: Bockhaus, Karl-Heinz Wolf, Hans Wocke, Johannes Haselof, Brunolf Baade, Freundel, Johannes Hoch. The subject is the '131' (EF 131) bomber, a drawing of which can be seen on Baade's desk.



Above: A model of the EF-131 bomber, showing the triple engine nacelles and the shape of the horizontal tail.



A drawing of the EF-131 from the captured project documents with additional Russian notes; the position of the fuselage frames is marked in the side view. This design of the cockpit section was typical of Junkers bombers developed at the closing stage of the war, such as the Ju 388.



A diagram showing the design of the Junkers Jumo 004B turbojet. Note the translating nozzle centrebody actuated by a screw-jack and the Riedel two-stroke starter in the intake centrebody.

describing this event: *'The take-off run, a 15-minute flight and the landing were performed well. The aircraft was piloted by a German pilot, Paul Julge, who is at present a pilot of Plant No.1. According to the pilot's assessment and observations from the ground, the aircraft possesses good flying characteristics within the limits set for the first flight. The aircraft took off at a speed of 250 km/h* [155 mph] *at an all-up weight of 17 tonnes* [37,485 lb]. *The maximum speed prescribed by the programme for the first flight was 350 km/h* [217 mph], *the landing speed was 220 km/h* [137 mph], *the level flight took place at an altitude of 1,400 m* [4,590 ft].

After the touch-down, during the landing run, a small incident took place. A bolt in the attachment of the port main gear fulcrum failed, the aircraft tilting to port and scraping the ground with one engine (out of a cluster of three engines).

...One of the aircraft's engines will be replaced, the minor damage caused by the landing gear collapse will be rectified and the flights will be resumed in three or four days.'

However, it proved impossible to complete the flight testing of the bomber by the stipulated date. The tests revealed such deficiencies as nosewheel shimmy and vibration of the tail surfaces; curing them took much time. By October 1947 the EF-131 had made only seven flights, logging 4.5 flight hours.

The protracted testing and development prevented the German aircraft from taking part in the Aviation Day flypast on 18th August. The nation's leaders reacted with increasing irritation to the breaches of the development schedule. N. I. Abramov, Director of GOZ No.1, was fired for failing to maintain the schedule. In September 1947 Mikhail V. Khrunichev, the new Minister of Aircraft Industry, wrote to the plant's acting director S. L. Rebenko and to Baade:

'Tests and development of prototype aircraft designed by your plant's OKB-1 have been organised in an utterly unsatisfactory way and, as a consequence, are proceeding at an impermissibly slow tempo. I oblige you:

1. [...]

2. To complete the flight tests of the EF-131 aircraft No.1, in accordance with the programme endorsed by me, in October of this year, and to submit to me the report on the testing by 1st November of this year.

I warn you about your personal responsibility for implementing these instructions strictly within the time limits I have specified.'

Still, this programme was not fulfilled either. In October 1947, in connection with the ban imposed on the presence of foreign specialists at facilities engaged in classified research and development work, an order was issued calling a halt to the testing of the German aircraft at LII; the aircraft and the specialists were sent back to the plant. For several months the EF-131 prototype sat on the airfield, covered with snow. In consequence, as revealed by a subsequent inspection, many rubber parts and wiring components deteriorated and had to be replaced. The overhaul and repairs took several months.

A new round of pre-flight preparations for the testing of the EF-131 bomber was completed in June 1948. Again, the tests were to be conducted at the LII airfield; yet, they never started. On 21st June all work on the aircraft was discontinued pursuant to order No.440 issued by the Minister of Aircraft Industry.

Some documents state that 15 test flights totalling 11 hours were performed on the EF-131 bomber. These flights made it possible to study the techniques of piloting a high-speed heavy aircraft, methods of its combat use and operational characteristics of an aircraft featuring an unusual layout and design.

Resolution No.3206-1301 on terminating the work on the bomber was issued somewhat later, on 23rd August. A decision was taken to start the development of a modified version of the EF-131 aircraft which was designated '140'. The decision to halt the testing of German jet aircraft was due to the emergence of a new generation of Soviet turbojet engines which were superior in performance to German engines. These were the AM-TRDK-01 designed by A. A. Mikulin and the TR-1 designed by A. M. Lyulka. The EF-131 powered by clusters of low-thrust Jumo engines under the wings was already an obsolescent machine.

Specifications of the EF-131 aircraft

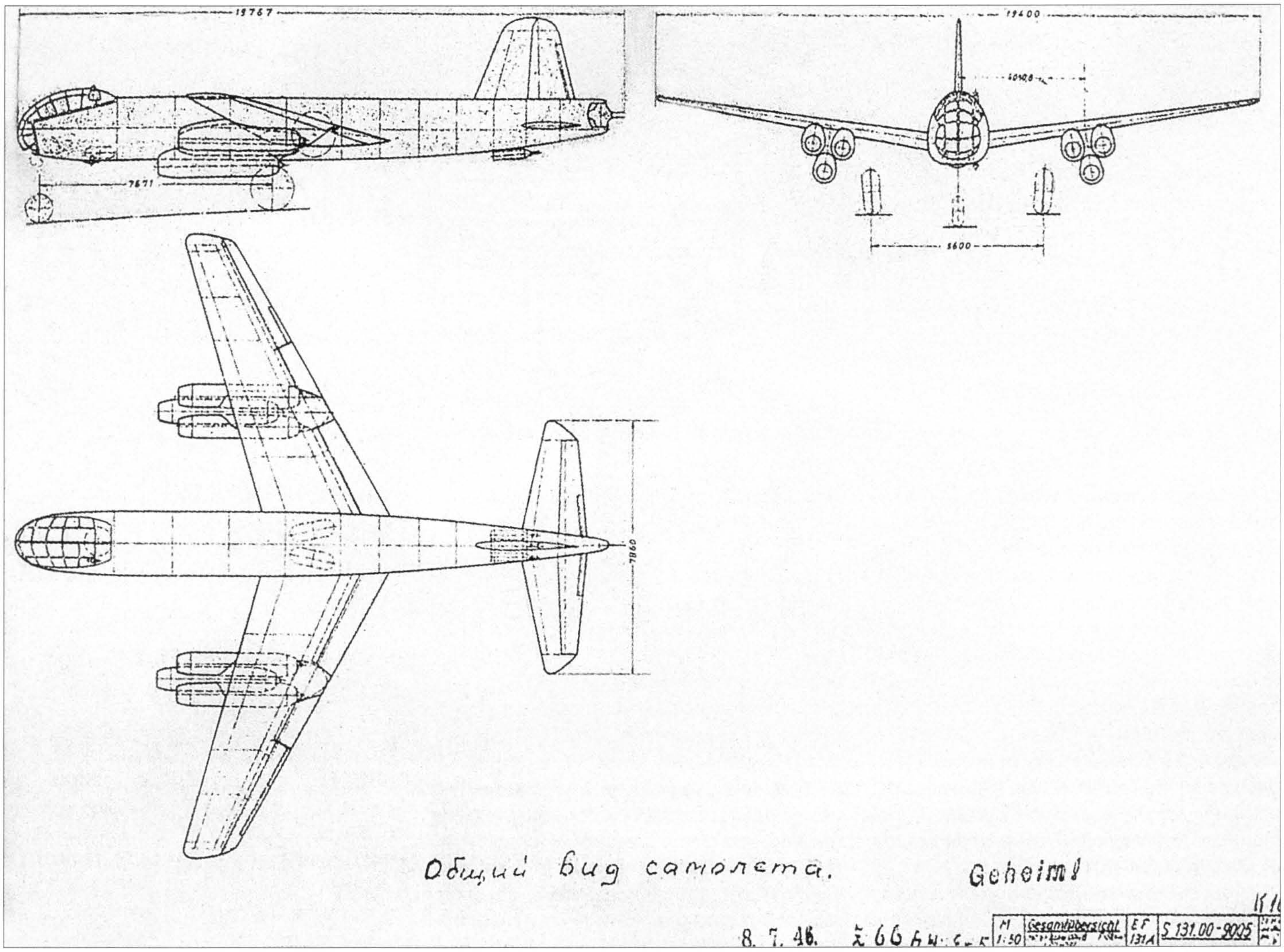
Powerplant	6 x Jumo 004B
Thrust, kg (lb)	6 x 900 (6 x 1,984)
Length overall	20.47 m (67 ft 2 in)
Height on ground	5.7 m (18 ft 8½ in)
Wing span	19.4 m (63 ft 7¾ in)
Maximum speed, km/h (mph)	860* (534)
Landing speed, km/h (mph)	190* (118)
Range, km (miles)	1,710* (1,063)
Service ceiling, m (ft)	12,500* (41,000)
Fuel load, kg (lb)	7,150 (15,765)
Armament, mm	2 x 13
Bomb load, kg (lb)	2,000 (4,410)
Take-off weight, kg (lb)	22,955 (50,620)
Crew	3

* estimated

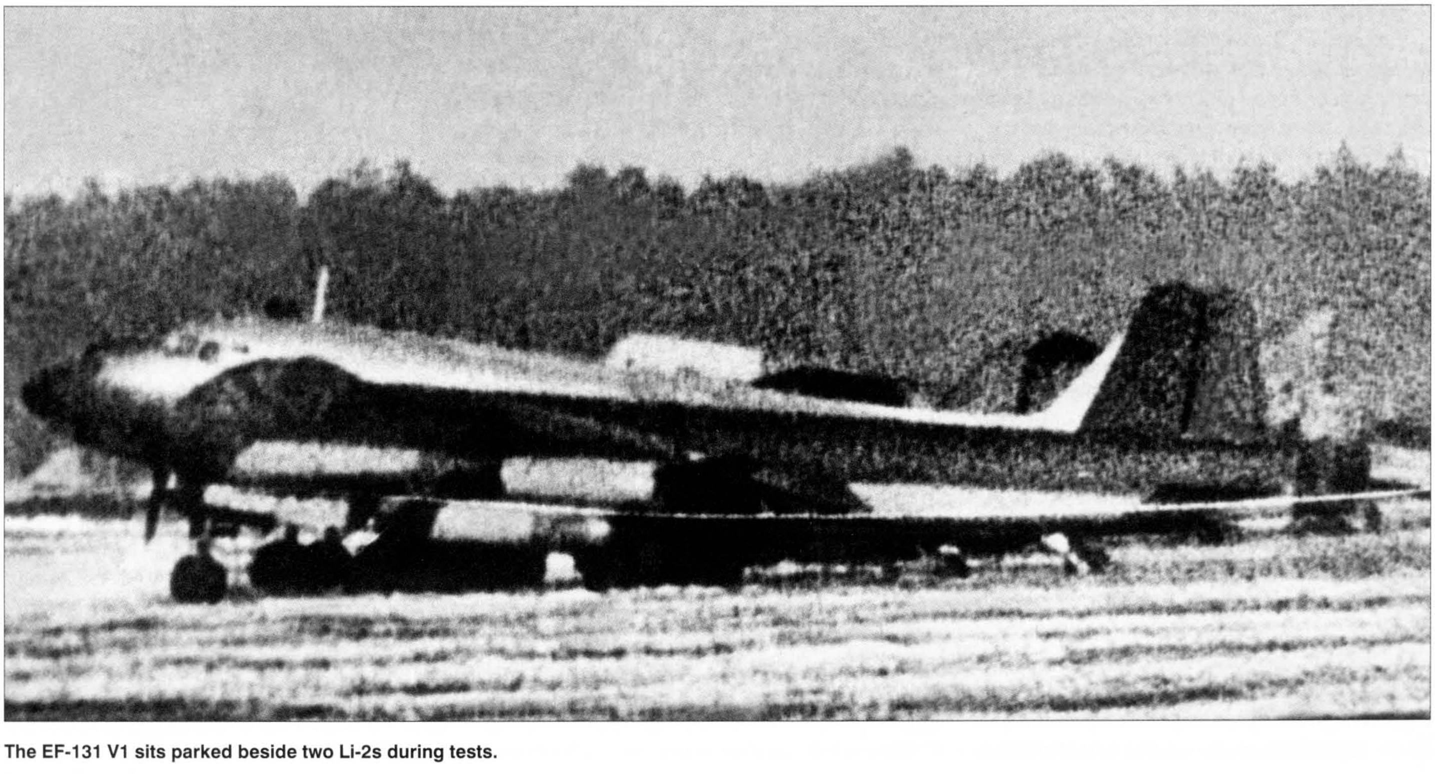
EF-132 (Ju 132 6AM-TKRD-01) long-range bomber (project)

The work on the EF-132 bomber was also initiated in 1945 in Germany. The official commencement of the design work must also be dated 17th April 1946 when, in accordance with the aforementioned CofM directive No.874-266, Chief Designer Baade was tasked with building a high-speed jet bomber powered by six Jumo 012 engines and submitting it for tests.

In August 1946 the advanced development project was completed in Germany and detail design was initiated. The aircraft's design performance included a maximum speed of 950 km/h (590 mph), a bomb load of 4,000 kg (8,820 lb) and a range of 2,250 km (1,398 miles).



Above: A three-view of the EF 131 prepared in 1946. The landing gear design is noteworthy: the nosewheel rotates through 90° during retraction to lie horizontally, while the mainwheels rotate around the oleos to stow vertically side by side. Note the JATO boosters under the rear fuselage.



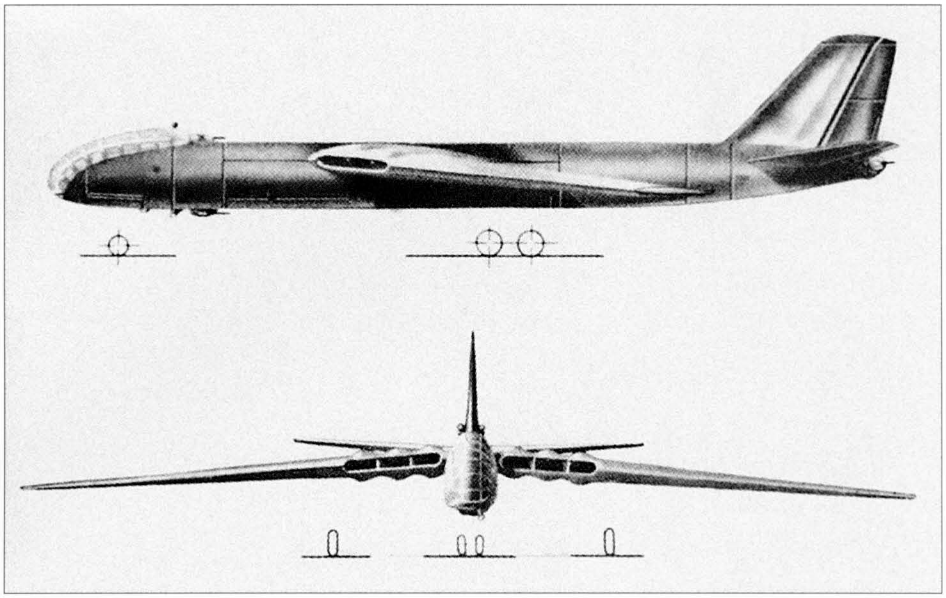
The EF-131 V1 sits parked beside two Li-2s during tests.

After the transfer of the work to GOZ No.1, MAP issued order No.207 dated 15th April 1947 which tasked the plant's OKB with reworking the advanced development project to accept six Soviet Mikulin AM-TKRD-01 turbojets rated at 3,300 kgp (7,280 lbst) at sea level; two prototypes of the EF-132 long-range bomber were to be built and submitted for testing by September 1948.

The ADP of the bomber with the new powerplant was endorsed on 10th October 1947; in some documents it was referred to as the Ju 132 6AM-TKRD-01, Ju being spelled in Cyrillic (Ю-132 6АМ-ТКРД-01). With six AM-TKRD-01 engines the aircraft had a design empty weight of 46,050 kg (101,540 lb) and a normal AUW of 90,150 kg (198,780 lb), including a fuel load of 39,200 kg (86,436 lb). Installation of JATO rockets permitted an increase of the AUW to 93,750 kg (206,718 lb). The design wing loading was 376 kg/m^2 (77 lb/sq ft), the thrust loading at sea level was 4.62 kg/kgp (lb/lbst). At an AUW of 68,000 kg (149,940 lb) the design maximum speed of 980 km/h (609 mph) was attained at sea level; at 3,500 m (11,480 ft) it decreased to 960 km/h (597 mph) and at 10,000 m (32,800 ft) to 893 km/h (555 mph). The estimated service ceiling at the mentioned AUW was 13,300 m (43,620 ft). Estimated range with a normal fuel load of 39,200 kg (86,436 lb) and a bomb load of 4,000 kg (8,820 lb) was 4,000 km (2,486 miles); with a medium-sized bomb load it was 3,300 km (2,050 miles), decreasing to 2,300 km (1,429 miles) with a maximum bomb load.

The aircraft featured a more potent armament, too. The dorsal, ventral and tail turrets were to be equipped with two 20-mm (.78 calibre) cannon each, with an ammunition load of 500 rounds for each pair of guns. The armour plating of the crew cockpit weighed 500 kg (1,102 lb), the tail gunner's cockpit armour weighed 60 kg (132 lb). The project envisaged the installation of an EAP-476 electric autopilot, RSB-8B and 12RSU-10 radios (transmitter and receiver respectively) and an SPU-14 intercom. Provision was made for the installation of the Bariy (Barium) and Magniy (Magnesium) IFF systems and the Materik (Continent) instrument landing system that were standard for the second half of the 1940s. Two aerial cameras could be installed in case of need. Electric power was to be supplied by two 5-kW generators, supplemented by two storage batteries with a capacity of 54 A·h each.

In 1947 the full-size mock-up was under construction and detail design got under way. Some systems and subassemblies, such as the landing gear and cannon turrets, were ordered from other factories. The Plant's aerodynamics laboratory conducted wind tunnel tests. Generally, however, the tempo of the work fell behind schedule. It became obvious that it would be impossible to start the testing at the prescribed time. In December studies were made for fitting the bomber with engines designed by Arkhip M. Lyul'ka's OKB-165. But the work did not progress any further: on 12th June 1948, pursuant to Council of Ministers' directive No.2058-805, all work on the EF-132 was terminated.


Two views of the projected EF-132 bomber. The main landing gear units retracted outwards. Note the remote-controlled dorsal, ventral and tail turrets.

'140' (EF-140) bomber prototype

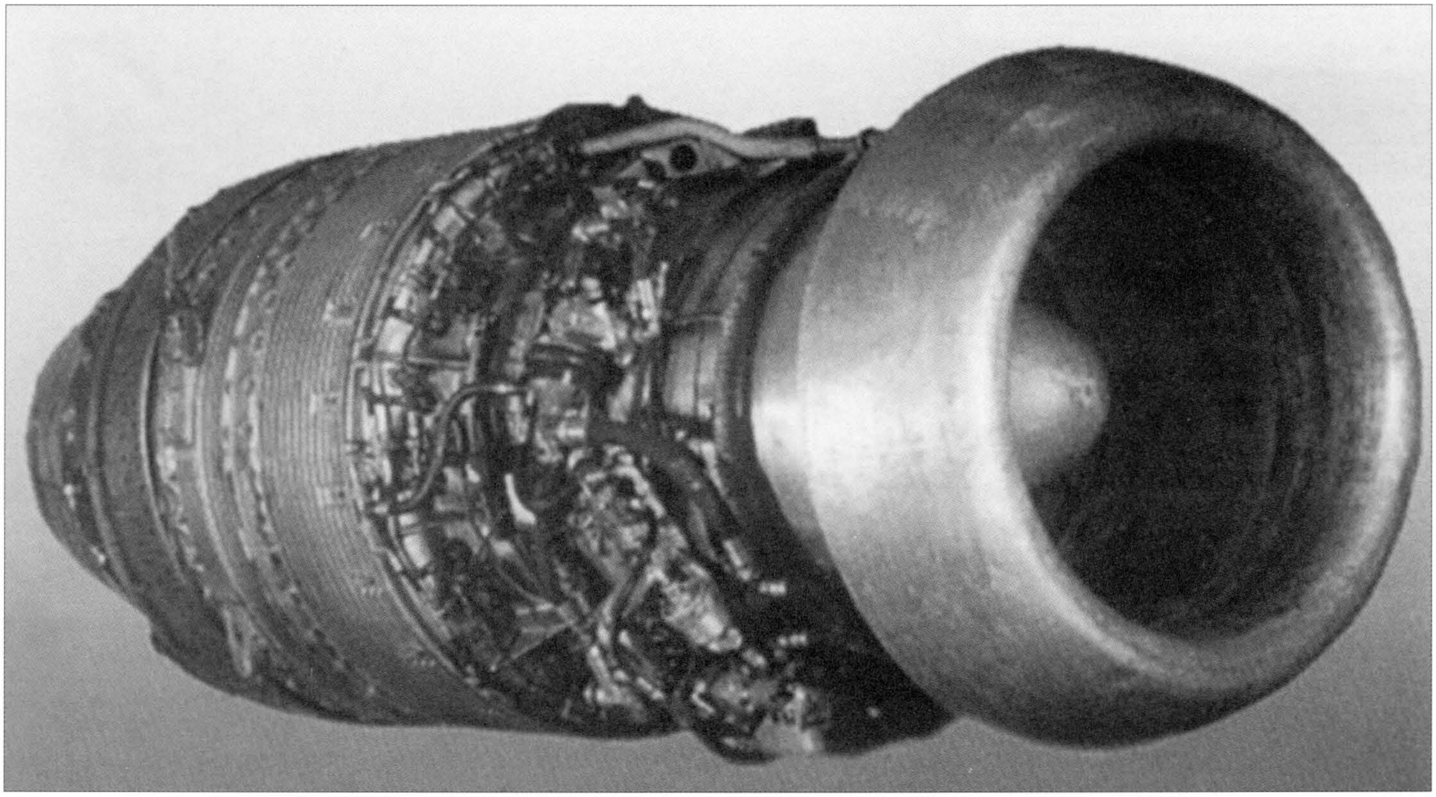
As related above, pursuant to Council of Ministers' directive No.3206-1301 dated 23rd August 1948, all work on the EF-131 aircraft with forward-swept wings was halted and a decision was taken to develop and build its twin-engined version which was allocated the designation '140'.

It is worth noting that the aircraft had its inception as early as 1947 as the EF-140 project developed at the initiative of OKB-1 headed by Baade. (German designers persisted in giving new aircraft designations in accordance with their traditional system, but in the Soviet Union this system was 'broken down' at an early stage so as not to draw undue attention to the 'authorship' of the machines.)

The '140' aircraft (for security reasons it was referred to in some documents as aircraft '001') was intended to fulfil the mission of a fast high-altitude tactical jet bomber. When fitted with special aerial cameras, it could be used as long-range day and night reconnaissance aircraft. The range could be increased by replacing part of the bomb load by drop tanks installed in the bomb bay. The '140' was

Design performance characteristics of the EF-132

Powerplant	6 x Jumo 012	6 x AM-TKRD-01
Thrust, kgp (lbst)	6 x 3,000 (6 x 6,615)	6 x 3,300 (6 x 7,280)
Length overall	39,4 m (129 ft 3⅛ in)	38,475 m (126 ft 2 ¾ in)
Height on ground	8.0 m (26 ft 3 in)	8.65 m (28 ft 4½ in)
Wing span	34.4 m (112 ft 10⅜ in)	36.4 m (119 ft 5 in)
Tailplane span	n.a.	13.2 m (43 ft 3⅝ in)
Wing area, m^2 (sq ft)	n.a.	240.0 (2,583)
Maximum speed, km/h (mph)	950 (590)	980 (609)
Landing speed, km/h (mph)	170 (106)	n.a.
Range, km (miles)	3,900 (2,423)	4,000 (2,486)
Service ceiling, m (ft)	11,400 (37,390)	13,300 (43,624)
Fuel load, kg (lb)	40,900 (90,180)	39,200 (86,440)
Empty weight, kg (lb)	n.a.	46,050 (101,540)
Take-off weight, kg (lb)	87,500 (192,937)	90,150 (198,780)
Bomb load, kg (lb):		
normal	4,000 (8,820)	4,000 (8,820)
maximum	n.a.	18,000 (39,690)
Armament, mm	4 x 15	6 x 20
Crew	5	7



Above: The Mikulin AM-TKRD-01 turbojet. The nose fairing was designed to form part of the engine nacelle.

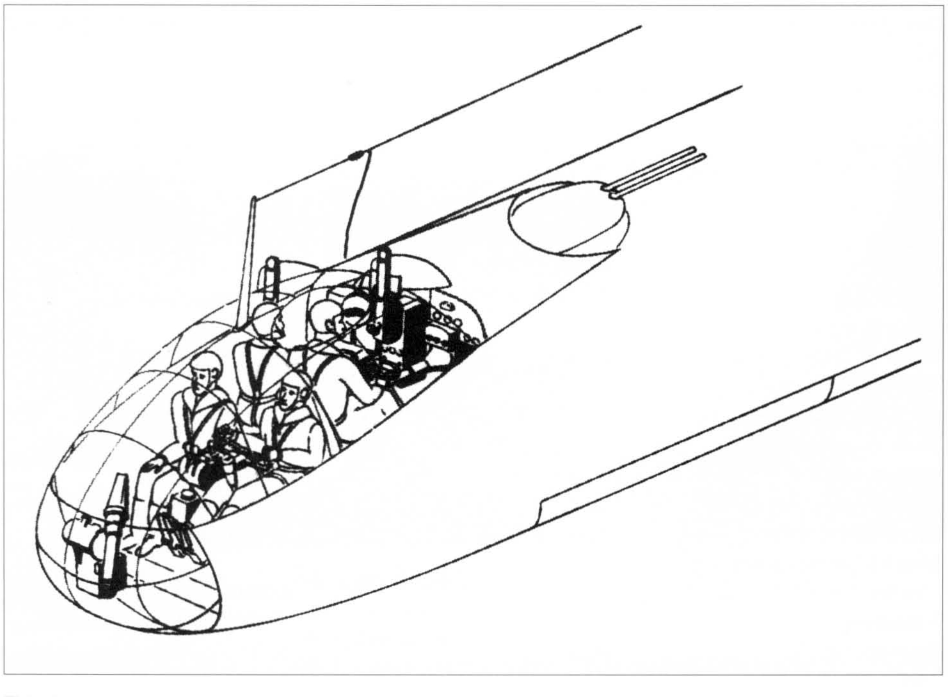
an all-metal monoplane with mid-set forward-swept wings. As distinct from its progenitor, the EF-131 prototype bomber, the '140' aircraft was powered by two Mikulin AM-TKRD-01 axial-flow turbojets, one under each wing. The thrust of the Soviet engines – 3,300 kgp (7,280 lbst) – was considerably superior to that of the German Jumo 004Bs. The engine nacelles of the '140' were attached directly to the wing undersurface. The new powerplant necessitated a substantial redesign of the aircraft's fuel system.

The EF-131 had only one gun turret placed in the tail; there was no armour protection whatsoever; the aircraft's speed being its primary means of protection against enemy fighters. With the introduction of jet fighters into service this became obviously insufficient. Therefore the '140' was fitted with two turrets (dorsal and ventral), each carrying twin 20-mm (.78 calibre) cannons (each turret was provided with 250 rpg), the cockpit was protected with armour.

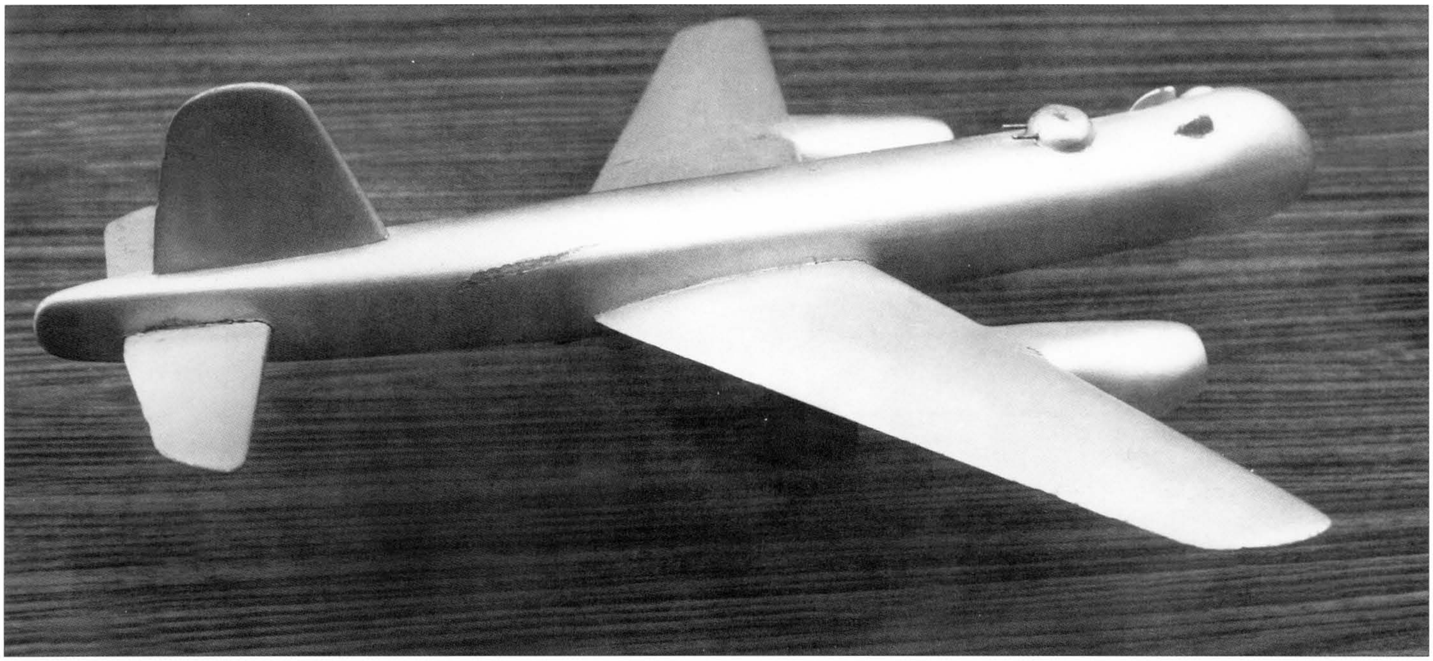
The bomber's crew was increased to four. The pilot sat in the left-hand forward seat, with the navigator/bomb-aimer on the right. Seated back-to-back behind the pilot was gunner of the dorsal turret; the radio-operator, doubling as the ventral turret gunner, sat facing aft behind the navigator. Armour plates (fixed plates with a thickness of 8-20 mm/0.31 -0.78 in, hinged plates with a thickness of 15-20 mm/0.59-0.78 in, and one movable plate) protected the crew against gunfire from the rear (in a cone with an angle of 15° and its apex at the aircraft's axis) and from below.

Bombs with a total weight of up to 4,500 kg (9,920 lb) were accommodated in the bomb bay in the centre fuselage. The bomb load options envisaged for the '140' are detailed in the table on page 38.

The equipment envisaged for use on the aircraft included the radio transmitter and receiver (RSB–5Ch and 12RSU-10 respectively) and the SPU-14 intercom. Provisions were made for the installation of Bariy and Litiy (Lithium) IFF transponders and the RUSP-45 ILS (***rah**diou**stroy**stvo* *sle**poy*** *po**sahd**ki* – blind-landing radio device) that were standard for the second half of the 1940s. Radio navigation equipment included the ARK-5 automatic direction finder and the RV-2 radio altimeter. One or two AFA-33/50 aerial cameras could be installed in case of need. Electric power was to be provided by two 9-kW GS-9000 generators.



This drawing illustrates the flightdeck layout of the '140', with the pilot and the navigator/bomb aimer facing forward and the dorsal gunner and the radio operator/ventral gunner facing the tail.

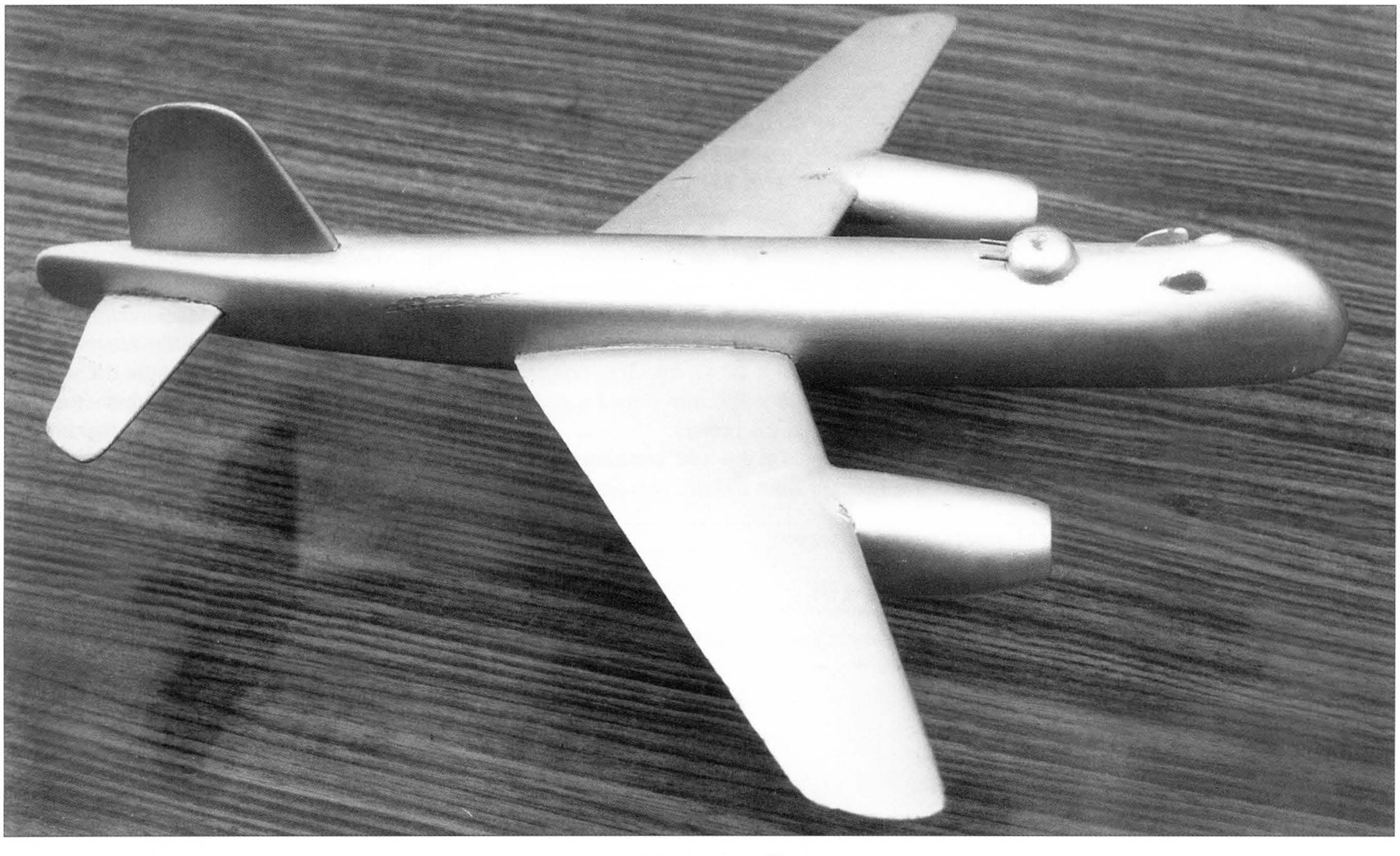


Above: A model of the '140' showing the dorsal turret and the faired rear vision periscopes used by the gunner.

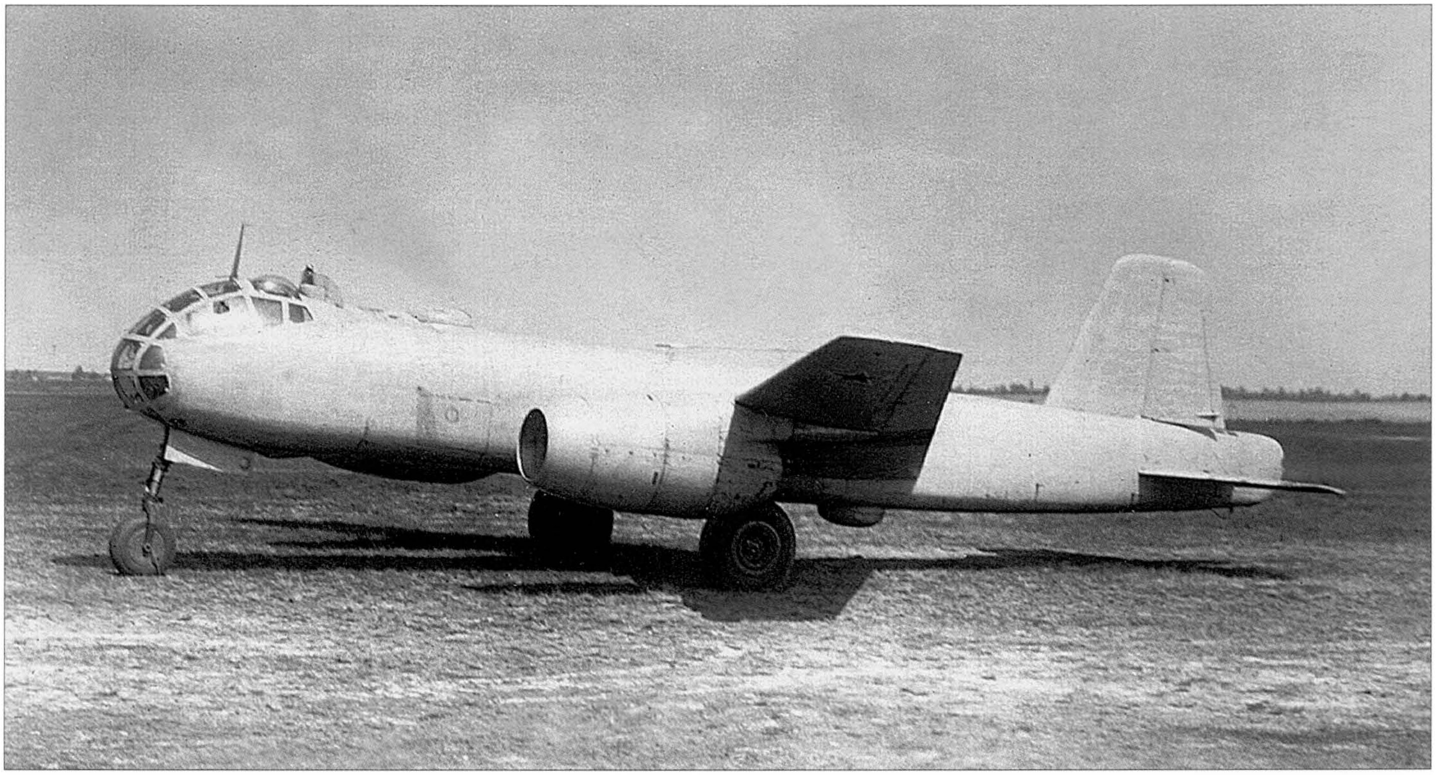
ADP development and mock-up construction were completed by 20th March 1948, and the manufacturing drawings by 31st March. The programme included a comprehensive range of tests and experiments; wind tunnel tests were conducted in TsAGI's T-106 wind tunnel.

After the mock-up inspection the results of the work so far accomplished were endorsed by the Government in the abovementioned CofM directive No.3206-1301. Construction of the prototype was considerably speeded up by using the second flying prototype of the EF-131 as a basis.

Manufacture of the aircraft was completed on 22nd July of that year. Between 7th and 10th August it was disassembled and transported to Tyoplyy Stan airfield where it was reassembled on 3rd September. (The airfield does not exist any more and the area is a residential district in the south-western part of Moscow.) Thus, it proved possible to proceed from the advanced development project drawings to the prototype flight testing within a matter of half a year which on the whole bears testimony to the tempo of work in the Soviet aircraft industry after the war.



Another view of the model, showing the distance between the engines and the fuselage. The shape of the extreme nose was more pointed on the actual aircraft.



The '140' prototype at Tyoplyy Stan airfield during initial flight tests; no armament has been fitted yet. This view illustrates the design of the engine pylons and the bomber's nose-up attitude on the ground. Note that the Soviet insignia is carried on the wings only.

The offensive weapons options of the '140' aircraft

Number of bombs	Calibre, kg (lb)	Bomb load, kg (lb)
1	1,500 (3,307)	1,500 (3,307)
3	500 (1,102)	1,500 (3,307)
5	250 (551)	1,250 (2,756)
1	3,000 (6,615)	3,000 (6,615)
2	1,500 (3,307)	3,000 (6,615)
6	500 (1,102)	3,000 (6,615)
10	250 (551)	2,500 (5,512)
9	500 (1,102)	4,500 (9,922)
15	250 (551)	3,750 (8,437)

The real flying prototype was virtually identical to the configuration envisaged by the ADP. The VDB-6 electrically actuated twin-cannon barbette was used as the dorsal turret (***verkh**nyaya distantsi**on**no ooprav**lya**yemaya **bahsh**nya* – dorsal remote-controlled turret), while the ventral barbette was of the NDB-1M type (***nizh**nyaya **verkh**nyaya distantsi**on**no ooprav**lya**yemaya **bahsh**nya*). The size of the mainwheels was enlarged to 1,450 x 520 mm (57 x 20.47 in) instead of 1,425 x 520 mm (56.1 x 20.47 in). The nosewheel measuring 900 x 350 mm (35.43 x 13.78 in) was left as per the project.

Flight tests of the '140' were conducted at the Tyoplyy Stan airfield. The first flight took place on 30th September and lasted about 20 minutes. As stated in the report on this flight, *'the take-off, level flight and landing proceeded normally'*. During the second flight which took place on 5th October some faults were revealed in the running of the engines. The unsatisfactory functioning of the so-called 'automatic fuel feed control' installed on the AM-TKRD-01 made manual control of the engine thrust extremely difficult; the engines spontaneously changed rpm, which was accompanied by jolts and swinging of the aircraft in flight. After the seventh flight the tests had to be suspended. Thus, by late 1948 the '140' had performed only seven flights, logging a total of 4 hours and 20 minutes.

In the first half of 1949 the development work on the aircraft went on. After the replacement of engines with a fresh shipset the testing was continued, and ten more flights were performed. The manufacturer's tests conducted by test-pilot I. Ye. Fyodorov were com-

Estimated range of the '140' aircraft (as per advanced development project)

Range, km (miles)	All-up weight, kg (lb)	Bomb load, kg (lb)	Fuel load, kg (lb)	Flight altitude, m (ft)	Speed, km/h (mph)
2,200	25,825	1,500	9,470	10,000-13,000	760-800
(1,367)	(56,994)	(3,307)	(20,880)	(32,800-42,640)	(472-528)
1,870	26,100	3,000	8,210	10,000-13,000	760-800
(1,162)	(57,550)	(6,615)	(18,103)	(32,800-42,640)	(472-528)
1,520	26,000	4,000	6,650	10,000-13,000	760-800
(945)	57,330)	(8,820)	(14,663)	(32,800-42,640)	(472-528)
1,300	25,550	4,500	6,110	10,000-13,000	760-800
(808)	(56,337)	(9,992)	(13,472)	(32,800-42,640)	(472-528)

pleted on 24th May 1949. Their results were as follows: the maximum speed was 904 km/h (562 mph) at an altitude of 3,000 m (9,840 ft) and 824 km/h (512 mph) at 11,000 m (36,090 ft); the range was 2,000 km (1,243 miles).

'140-R' tactical reconnaissance aircraft prototype

On 14th May 1949 the Council of Ministers issued directive No.1886-696 under the terms of which the work on the '140' aircraft was to be continued with a view to turning the bomber into a reconnaissance aircraft powered by Klimov VK-1 centrifugal-flow turbojets. The aircraft was allocated a new designation, '140-R' (ie, [*samo**lyot***-] *raz**ved**chik* – reconnaissance aircraft).

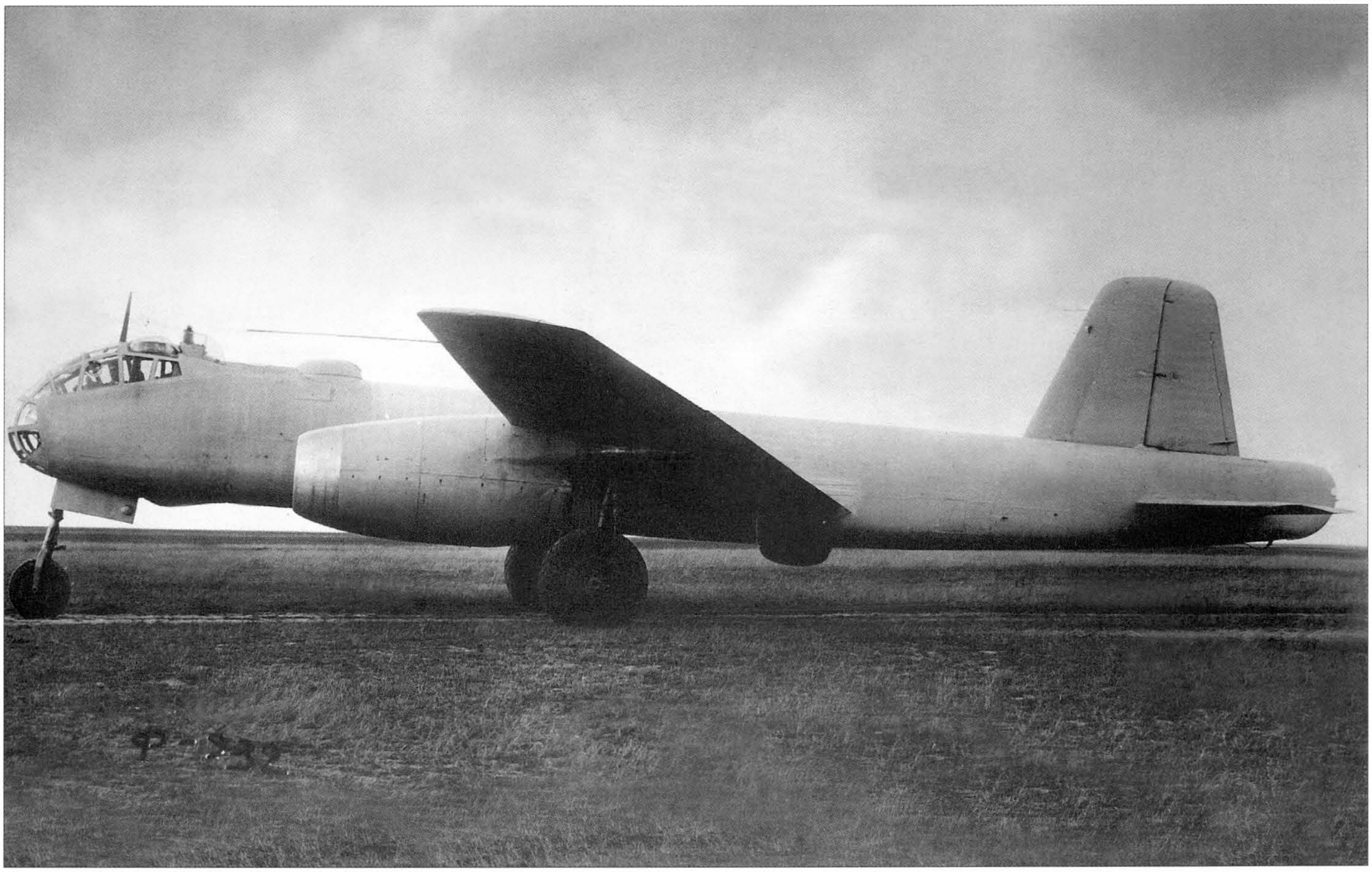
This long-range tactical reconnaissance aircraft was to be fitted with two VK-1 engines (a derivative of the Rolls-Royce Nene uprated to 2,700 kgp (5,950 lbst) for take-off) and possess a range in excess of 3,600 km (2,237 miles). The aircraft's project was developed in OKB-1's preliminary design projects section under the guidance of Hans Wocke. The complexity of the task stemmed from the very tight development schedule: the aircraft was to be submitted for State acceptance trials in September 1949. Nevertheless, the designers working on the '140-R' reconnaissance aircraft project succeeded in curing most of the deficiencies noted by the mock-up review commission which had inspected the mock-up of the '140' aircraft in March 1948, and in fulfilling almost all requirements associated with the aircraft's new mission (among other things, the requirements concerning the radio equipment).

The photo reconnaissance aircraft was expected to have a range of up to 3,600 km (2,237 miles) at an indicated airspeed of 635 km/h (395 mph) during flights at altitudes between 9,300 and 12,800 m (30,50-41,980 ft) with an AUW of 25,543 kg (56,322 lb). The design empty weight was 14,333 kg (31,604 lb); with four additional JATO rockets the maximum weight was to reach 26,503 kg (58,439 lb). The aircraft was expected to tale a fuel load of 10,600 kg (23,733 lb). With the mentioned weight characteristics, the design wing loading was 417 kg/m^2 (85.41 lb/sq ft). Maximum speed, at an AUW of 20,000 kg (44,100 lb), was to be 785 km/h (488 mph) at sea level and 837 km/h (520 mph) at 7,500 m (24,600 ft). At a reduced AUW of 17,000 kg (37,485 lb) the speed at the same altitude was expected to reach 850 km/h (528 mph). Time to 5,000 m (16,400 ft) was to be 8.6 minutes; the service ceiling was to be 14,100 m (46,248 ft). With four JATO rockets the take-off run should not exceed 980 m (3,215 ft), and the landing run with a brake parachute deployed was to be within 830 m (2,720 ft). The photo reconnaissance aircraft was to be fitted with the following equipment items: two 9-kW

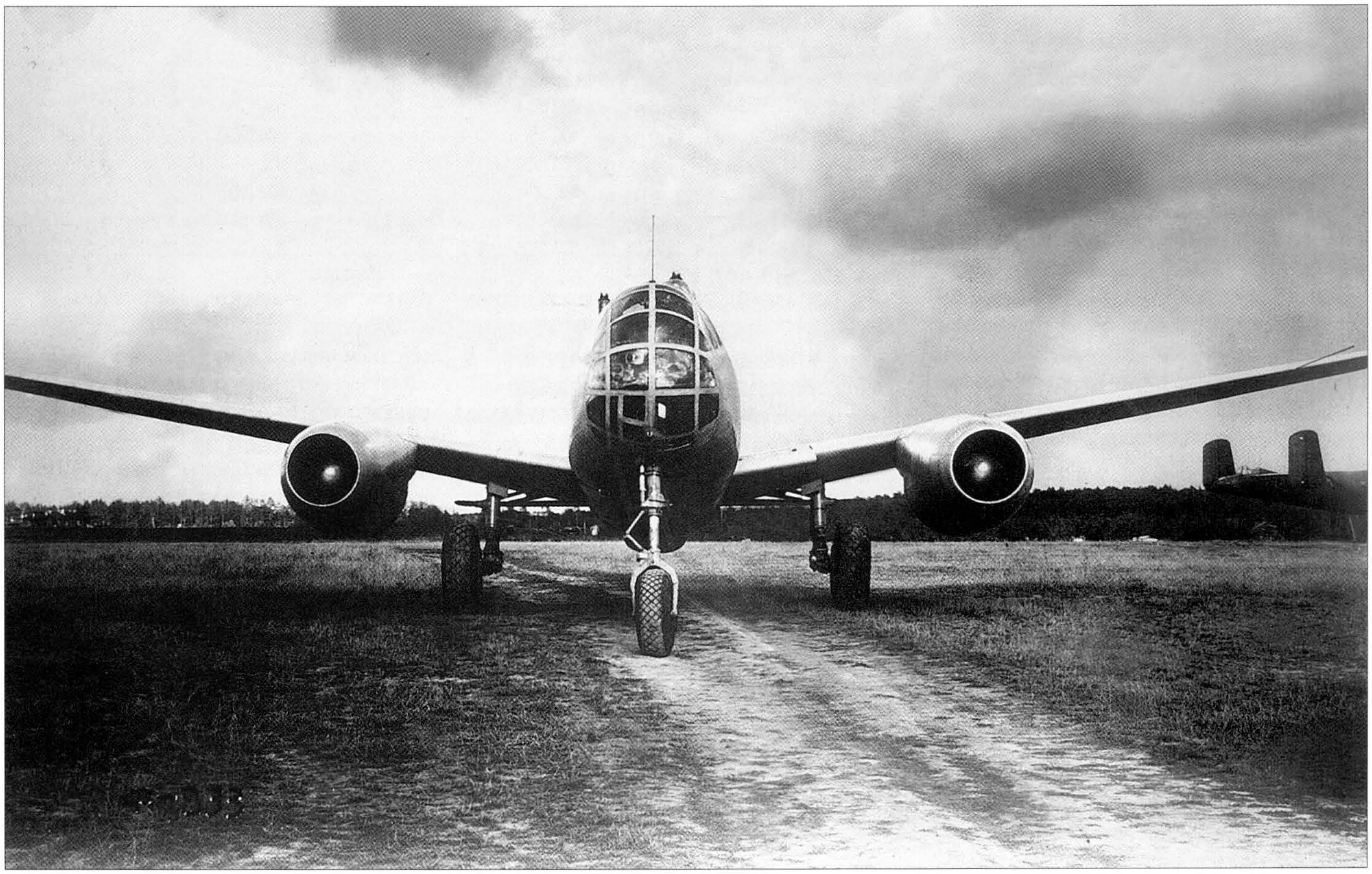
Dimensions and performance of the '140' aircraft

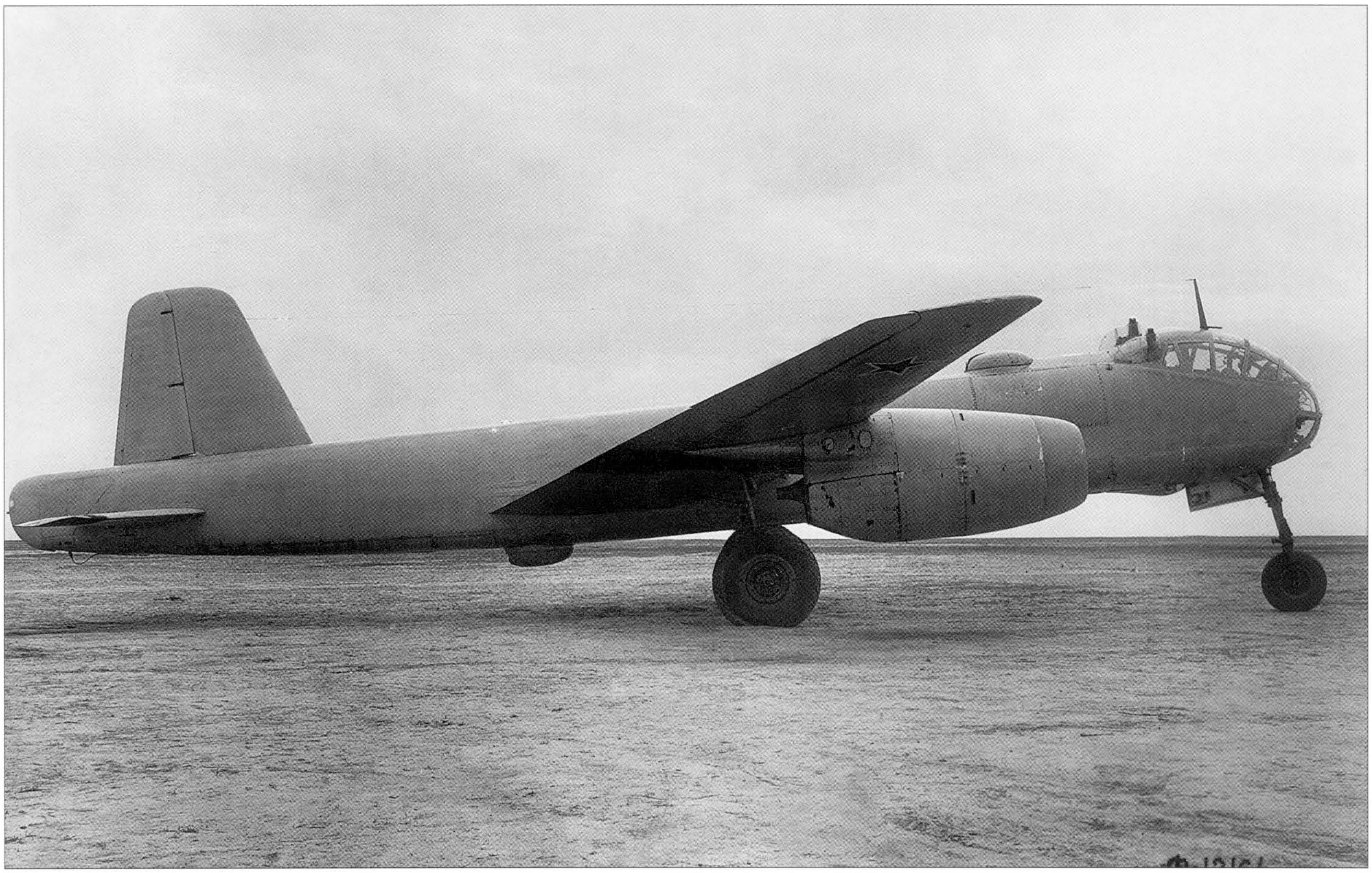
	As per advanced development project	As per manufacturer's flight test results
Engines	2 x AM-TKRD-01	2 x AM-TKRD-01
Thrust (nominal/take-off), kgp (lbst)	2 x 3,000/3,300 (2 x 6,615/7,276)	2 x 3,000/3,300 (2 x 6,615/7,276)
Length overall	19.6 m (64 ft 3⅝ in)	19.7 m (64 ft 7⅝ in)
Height on ground	5.7 m (18 ft 8⅜ in)	5.7 m (18 ft 8⅜ in)
Wing span	19.4 m (63 ft 7¾ in)	19.4 m (63 ft 7¾ in)
Wing area, m^2 (sq ft)	58.4 (628.67)	58.4 (628.67)
Wing aspect ratio	6.45	6.45
Aileron area, m^2 (sq ft)	3.25	n.a.
Tailplane span	7.86 m (25 ft 9½ in)	7.96 m (26 ft 1⅜ in)
Stabiliser area, m^2 (sq ft)	8.0 (86.12)	n.a.
Elevator area, m^2 (sq ft)	3.9 (41.98)	n.a.
Tailplane area, m^2 (sq ft)	11.9 (128.1)	11.91 (128.21)
Fin area, m^2 (sq ft)	3.5 (37.68)	n.a.
Rudder area m^2 (sq ft)	2.8 (30.14)	n.a.
Vertical tail area m^2 (sq ft)	6.3 (67.82) (5.95/64.05) [1]	6.0 (64.59)
Cockpit volume, m^3 (cu ft)	5.3 (57.05)	n.a.
Empty weight, kg (lb)	14,240 (31,400)	14,676 (32,360)
All-up weight, kg (lb):		
normal	n.a.	20,796 (45.846) [2]
maximum	24,500 (54,022) (25,825/56,944) [3]	25,220 3 (55,610)
absolute limit	27,000 (54,535)	n.a.
Landing weight, kg (lb)	16,500 (36,382)	n.a.
Fuel load, kg (lb):		
normal	n.a.	5,820 (12,830)
maximum	7,500 (16,540) (9,470/20,880) [1]	8,170 (18,010) [4]
Wing loading, kg/m^2 (lb/sq ft)	443 (90.7)	356 (72.9)
Thrust loading, kg/kgp (lb/lbst)	3.91 [5]	3.14
Maximum speed, km/h (mph):		
at sea level	860 (534)	n.a.
at 3,000m (9,840 ft)	n.a.	904 (562)
at 3,500 m (11,480.ft)	885 (550)	n.a.
at 5,000 m (16,400 ft)	n.a.	902 (560)
at 9,000 m (29,530.ft)	n.a.	860 (534)
at 10,000 (32,810 ft)	818 (508)	n.a.
Time to 5,000 m (16,400 ft), min	6.8	n.a.
Rate of climb, m/sec (ft/min):		
at sea level	15.8 (3,110)	n.a.
at 6,000 m (19.685ft)	9.2 (1,811)	n.a.
at 10,000 m (32,810 ft)	2.2 (433)	n.a.
Service ceiling, m (ft)	11,700 (38,380) [6]	11,000 (36,080) [7]
Tale-off run, m (ft)	880 (2,886) [8]	1,450 (4,756) [9]
Landing run, m (ft):		
with a brake parachute	750 (2,460)	950-1,000 [10] (3,115-3,280)

1. According to the results of weighing and measuring the aircraft after completion of manufacture
2. Without bombs
3. With a 1,500-kg (3,307-lb) bomb load and a maximum fuel load
4. With two auxiliary fuel tanks in two forward sections of the bomb bay
5. Estimated
6. At an AUW of 19,600 kg (43,218 lb)
7. Altitude actually attained
8. With four JATO rockets
9. At a landing weight of 20,000 kg (44,100 lb)
10. At a landing weight of 16,500 kg (36,380 lb)

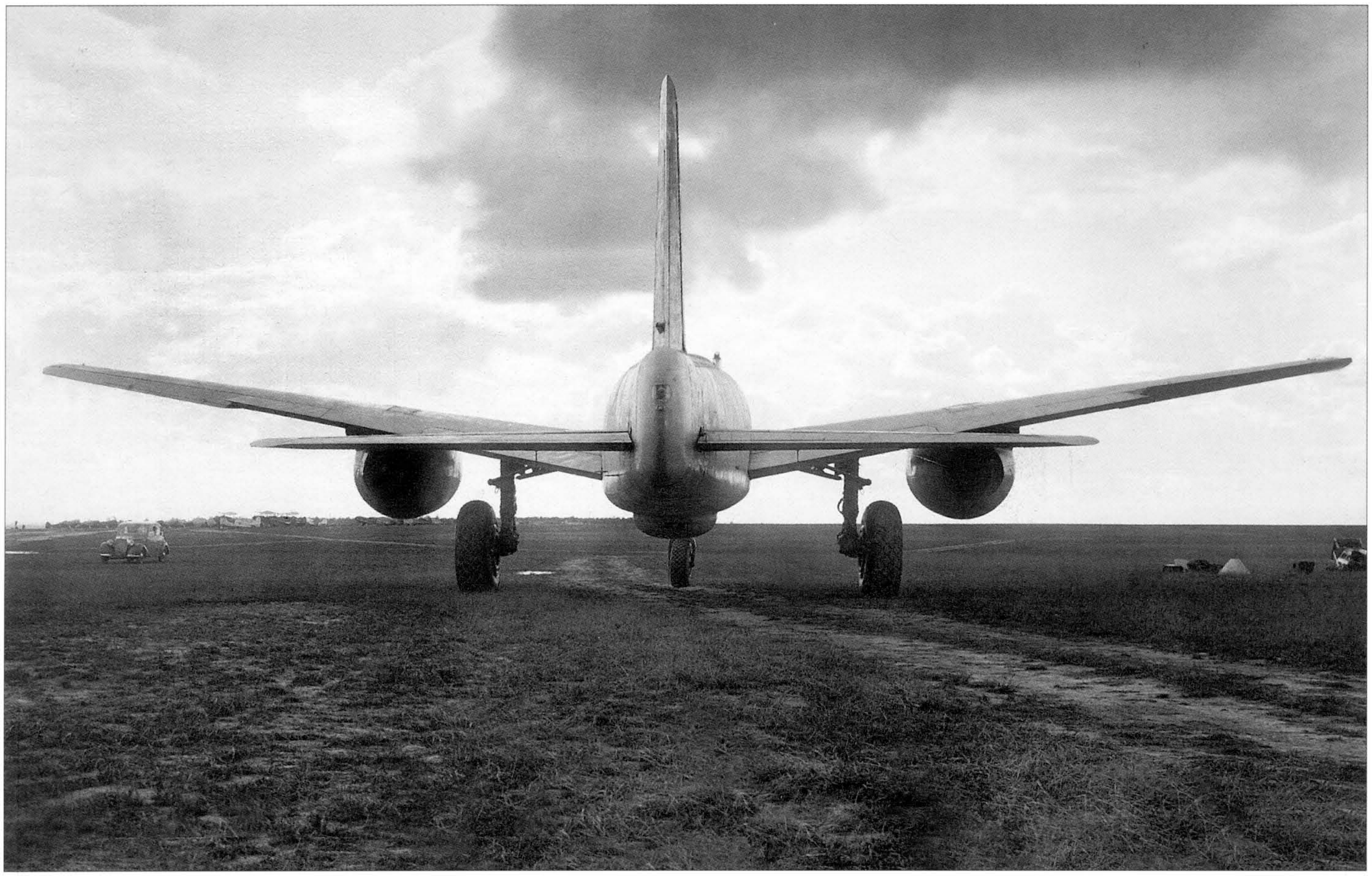


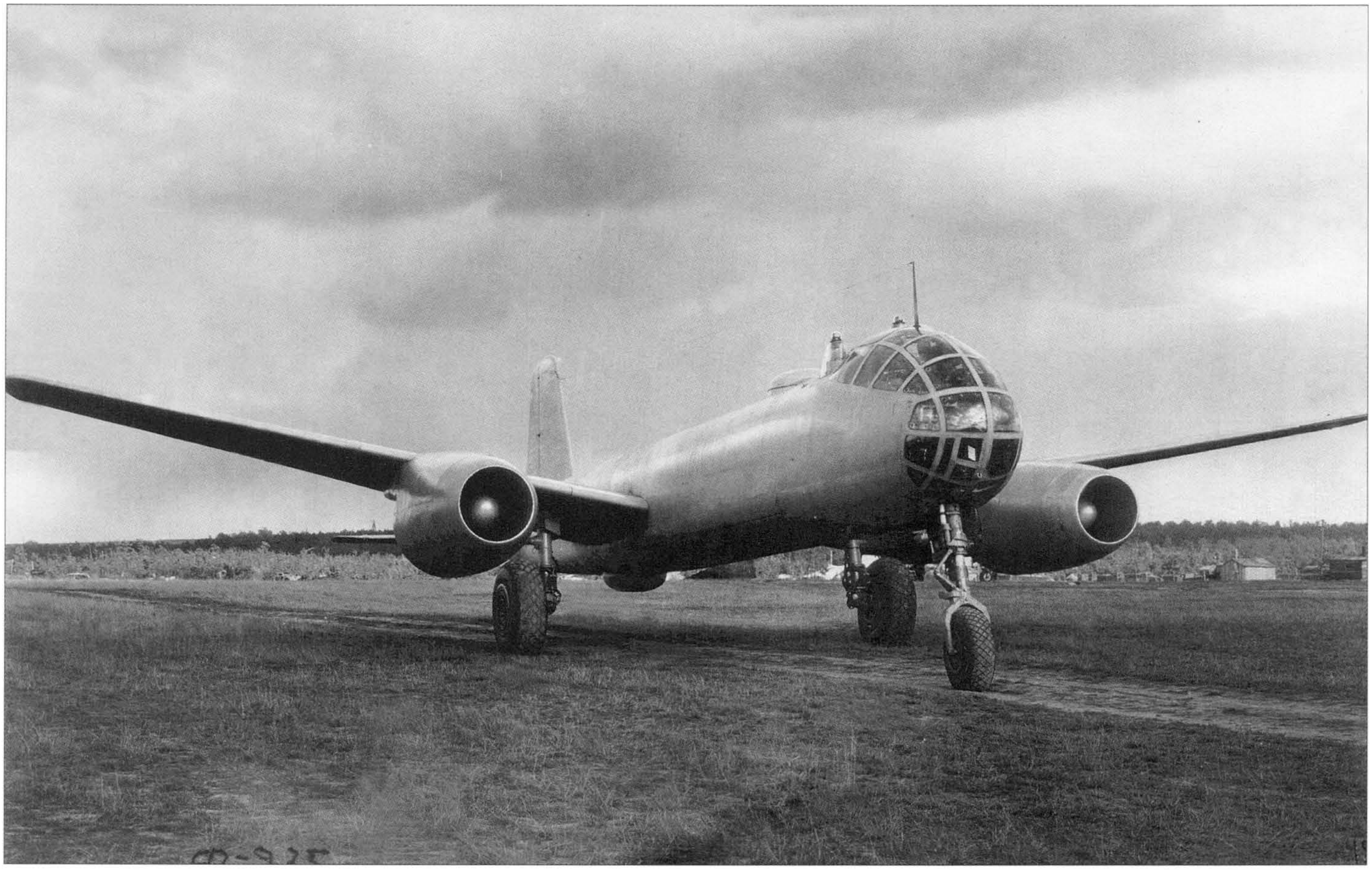
Above: Port side view of the '140'; note the forward inclination of the main gear oleos.
Below: Front view of the '140', showing the egg-shaped forward fuselage cross-section and the strong wing dihedral.



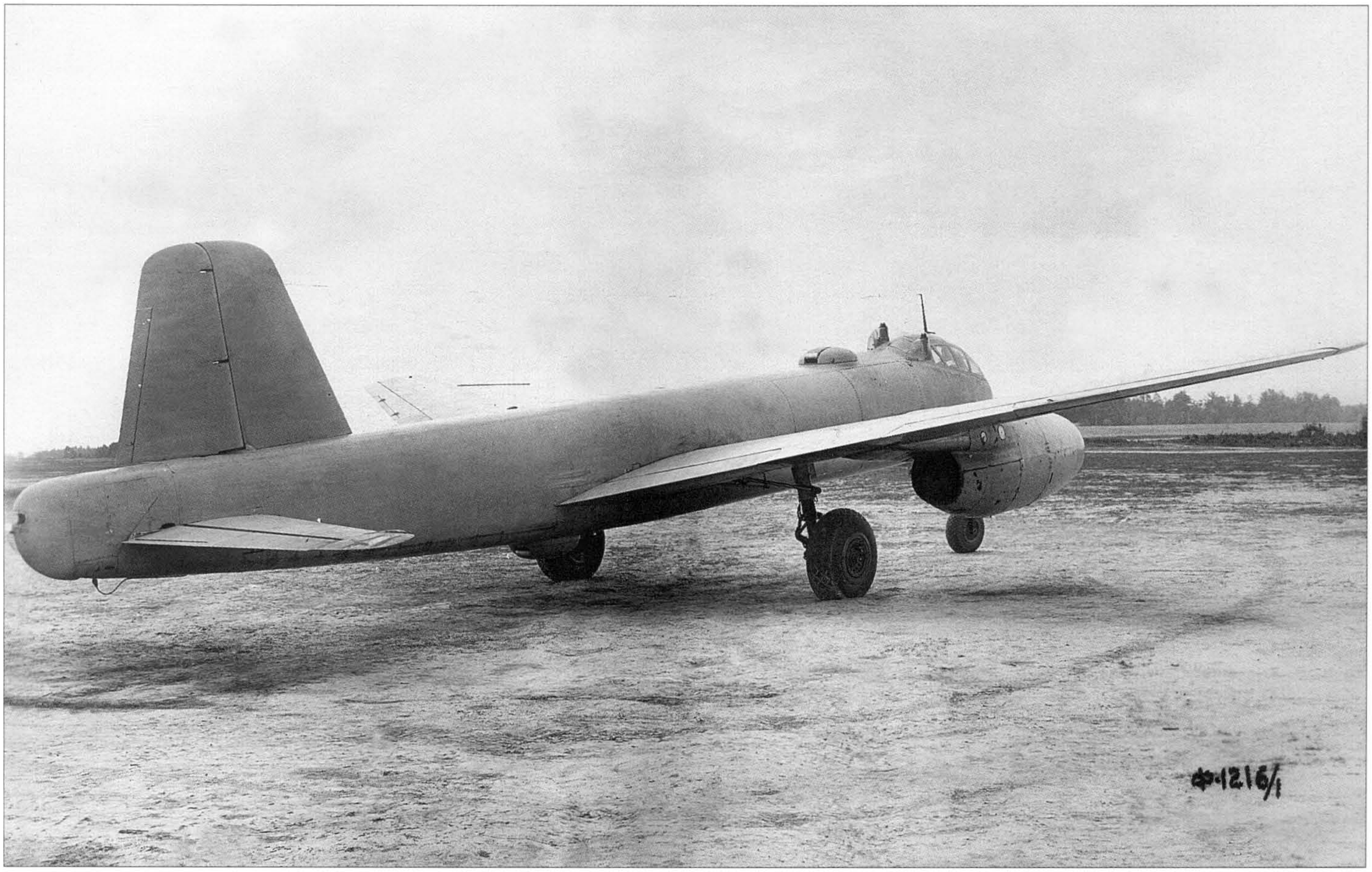


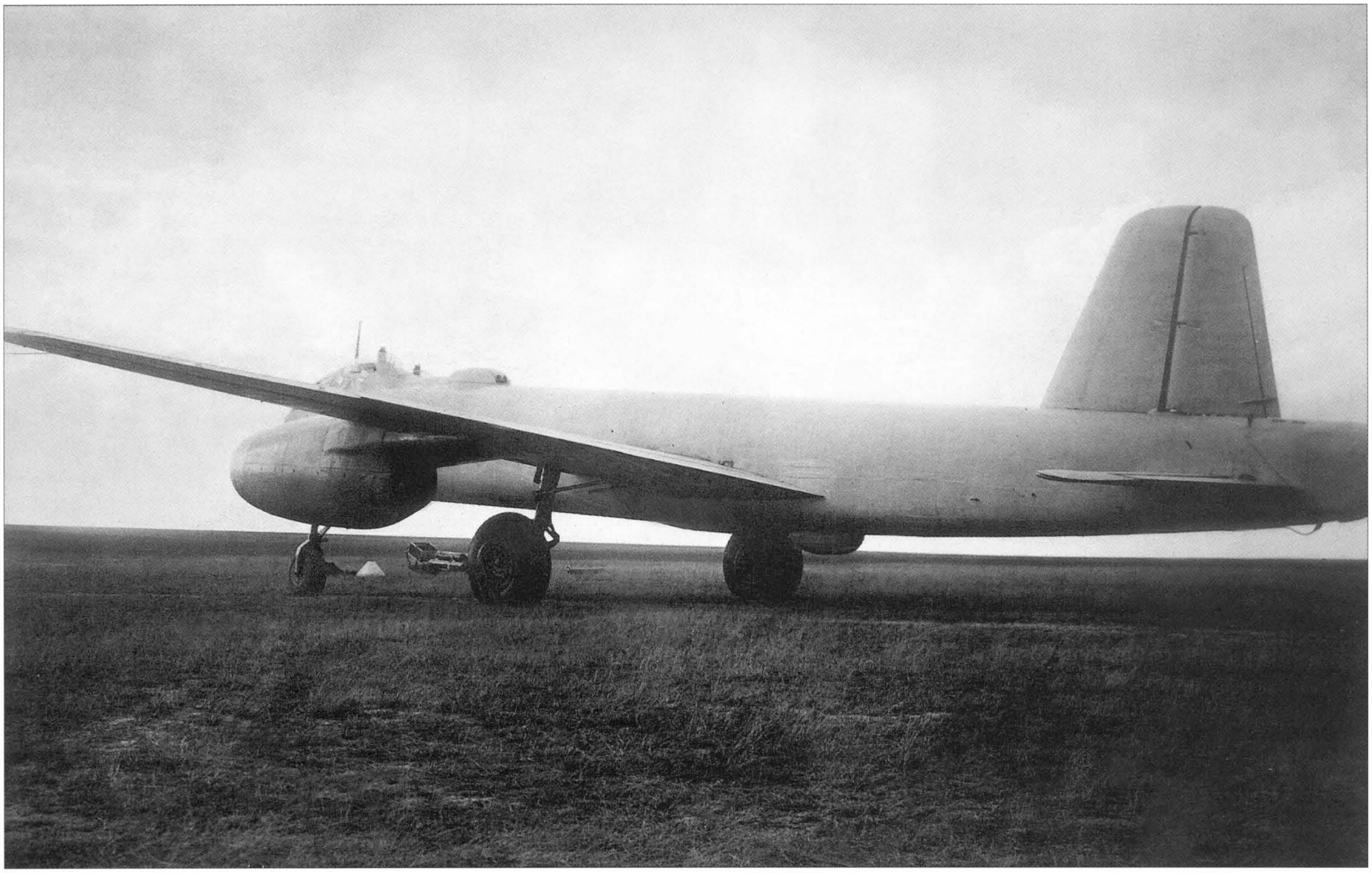
Above: Starboard side view of the '140'.
Below: Rear view of the '140'; unlike the wings, the horizontal tail had no dihedral.



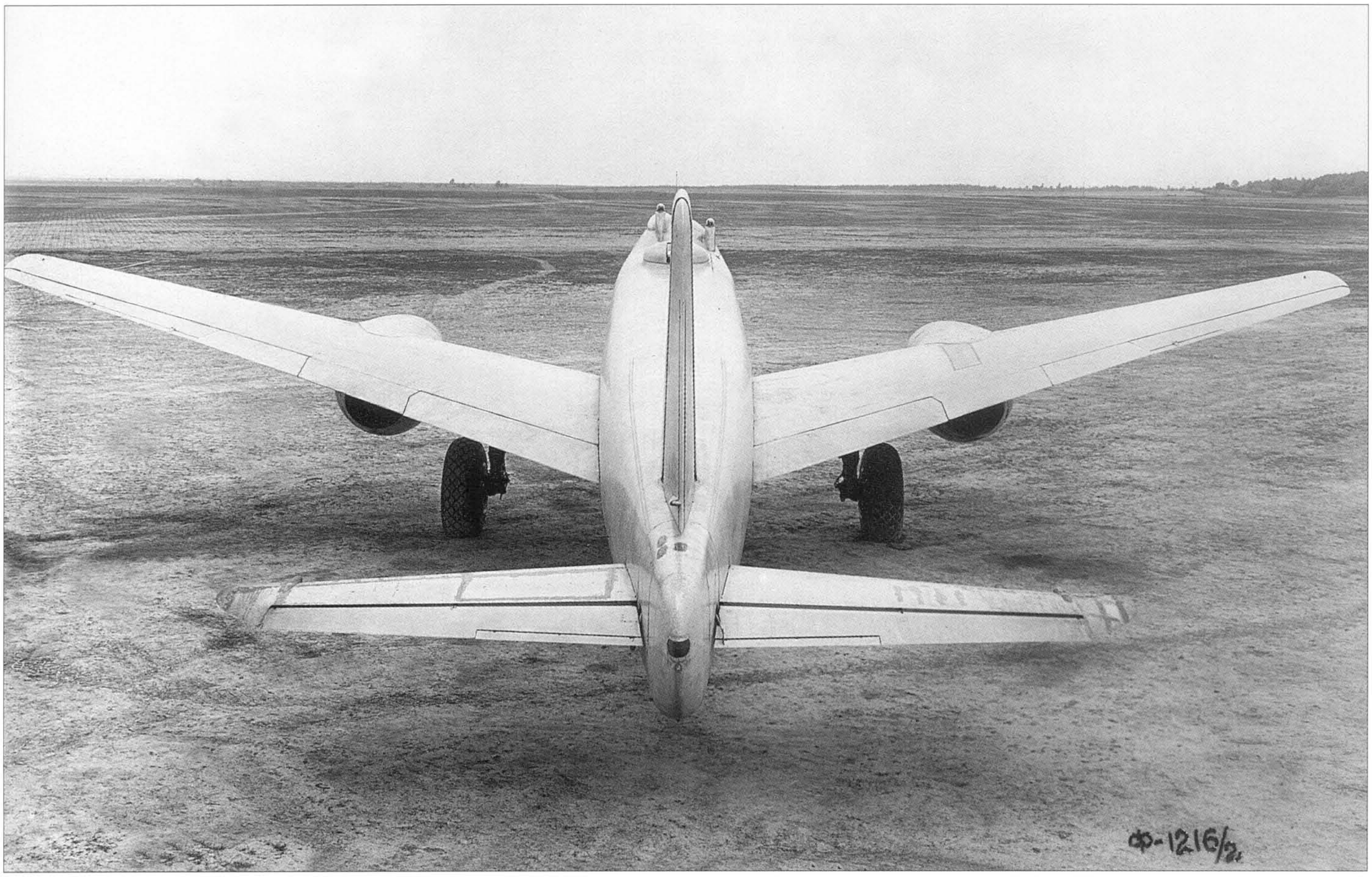


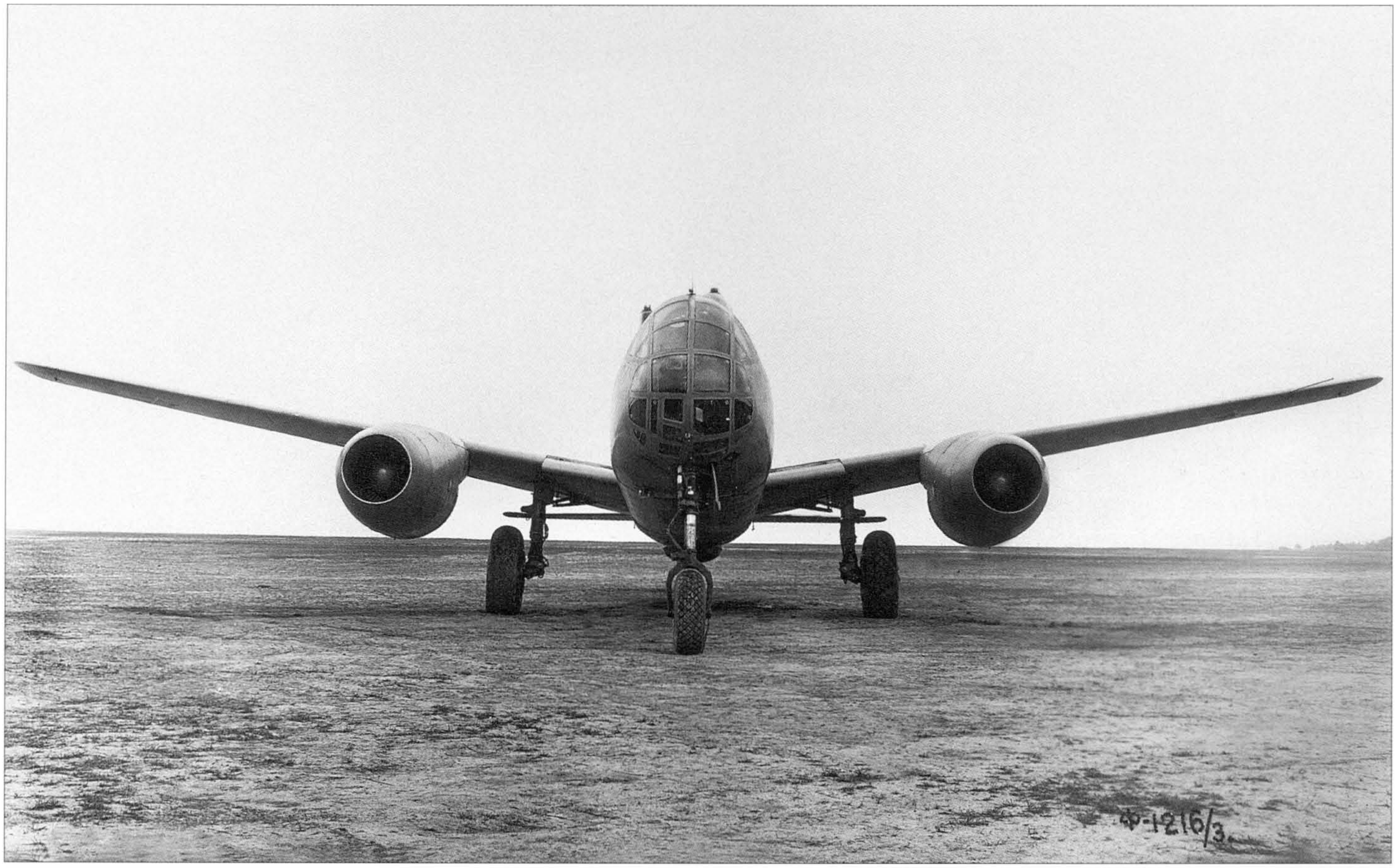
Above and below: Three-quarters front and rear views of the '140' at Tyoplyy Stan airfield during tests.



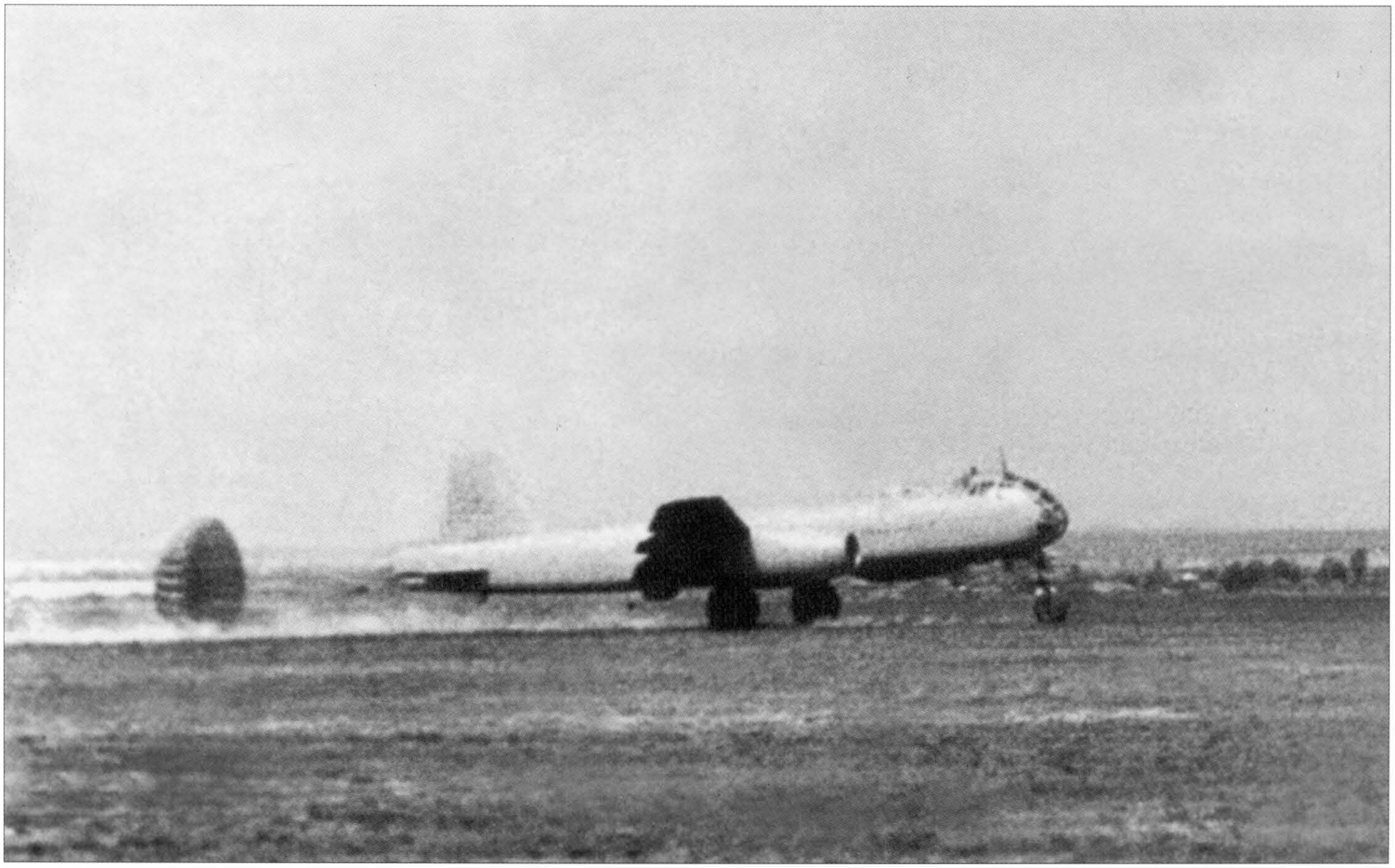


Above and below: Two more views of the '140'.





Above: Another front view of the '140'.



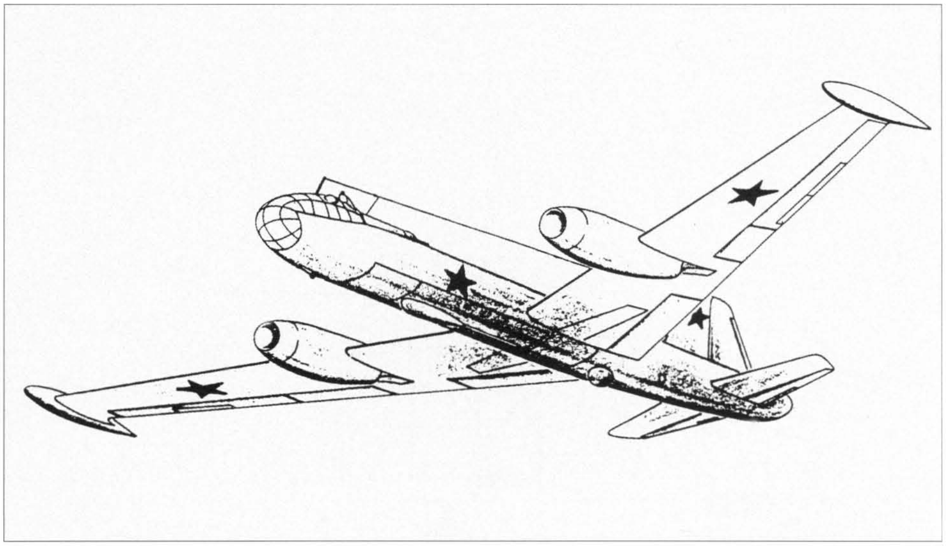
The '140' uses its brake parachute to shorten the landing run. The brake parachute bay was located ventrally.

GSR-9000 electric generators, an AP-5 autopilot, an RSIU-3 receiver and an RSB-5 transmitter, an SPU-5 intercom, RV-2 and RV-10 radio altimeters, Bariy-F IFF transponder and Materik instrument landing system, a PBSN bomb sight and four KP-14 breathing apparatus with eight 2-litre (0.44 Imp gal) oxygen bottles each. The mission equipment consisted of AFA-33/20, AFA-33/50 and AFA-33/100 day cameras or NAFA-3s/50 night cameras.

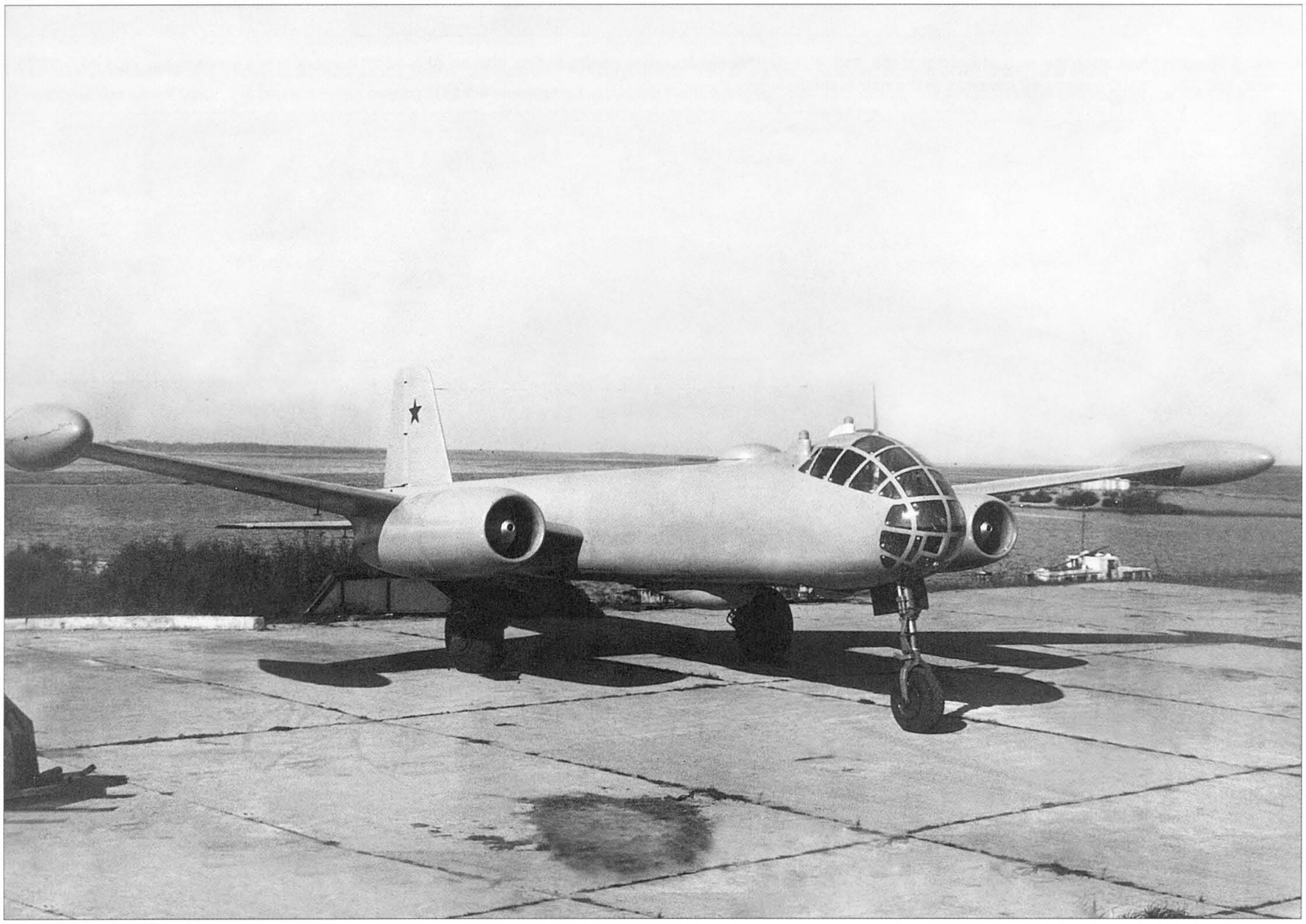
The advanced development project of the '140-R' aircraft was endorsed on 19th July 1949. In order to modify the '140' bomber prototype into a photo reconnaissance aircraft, the machine was disassembled (a process which took rather a long time) and then transported from the Tyoplyy Stan airfield to Plant No.1, where it was to undergo modification and be fitted with equipment intended for day and night reconnaissance (aerial cameras, flare bombs and the like) which was to be housed in the forward part of the internal stores bay and in the rear fuselage. Among other things, the aircraft was fitted with:

- new powerplant assemblies, including VK-1 engines and new engine nacelles;
- a new engine control system;
- an extra fuel tank in the fuselage;
- teardrop-shaped wing-tip fuel tanks which increased the wing span from 19.4 m (63 ft 7¾ in) to 21.87 m (71 ft 9 in);
- additional equipment for the carriage of flare bombs (eight SAB-100/75s or SAB-100/55s, or twelve FOTAB-50/35) and equipment for the installation of aerial cameras;
- additional electric equipment;
- new armament.

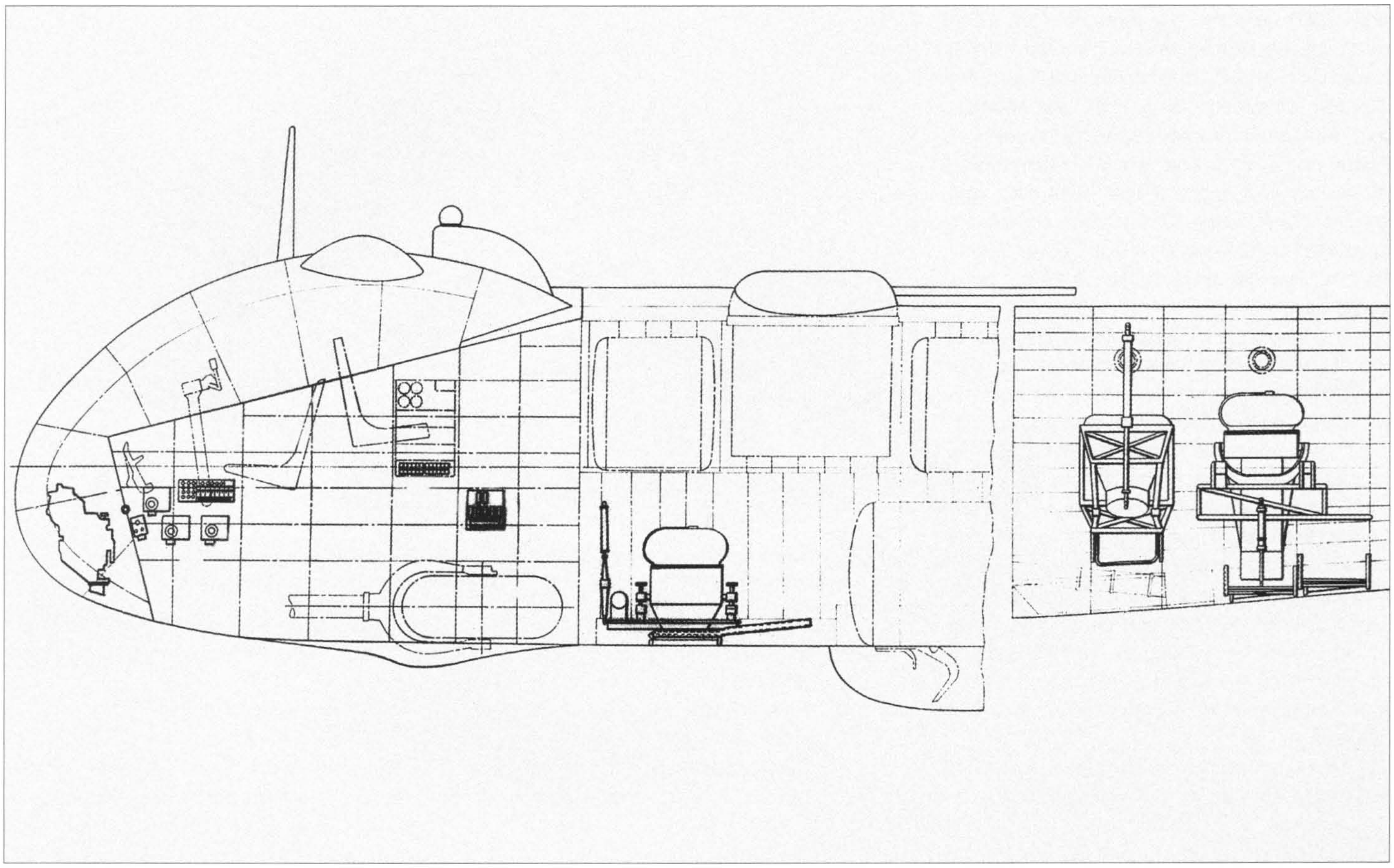
The aircraft was fitted with two remote-controlled powered barbettes, each mount-



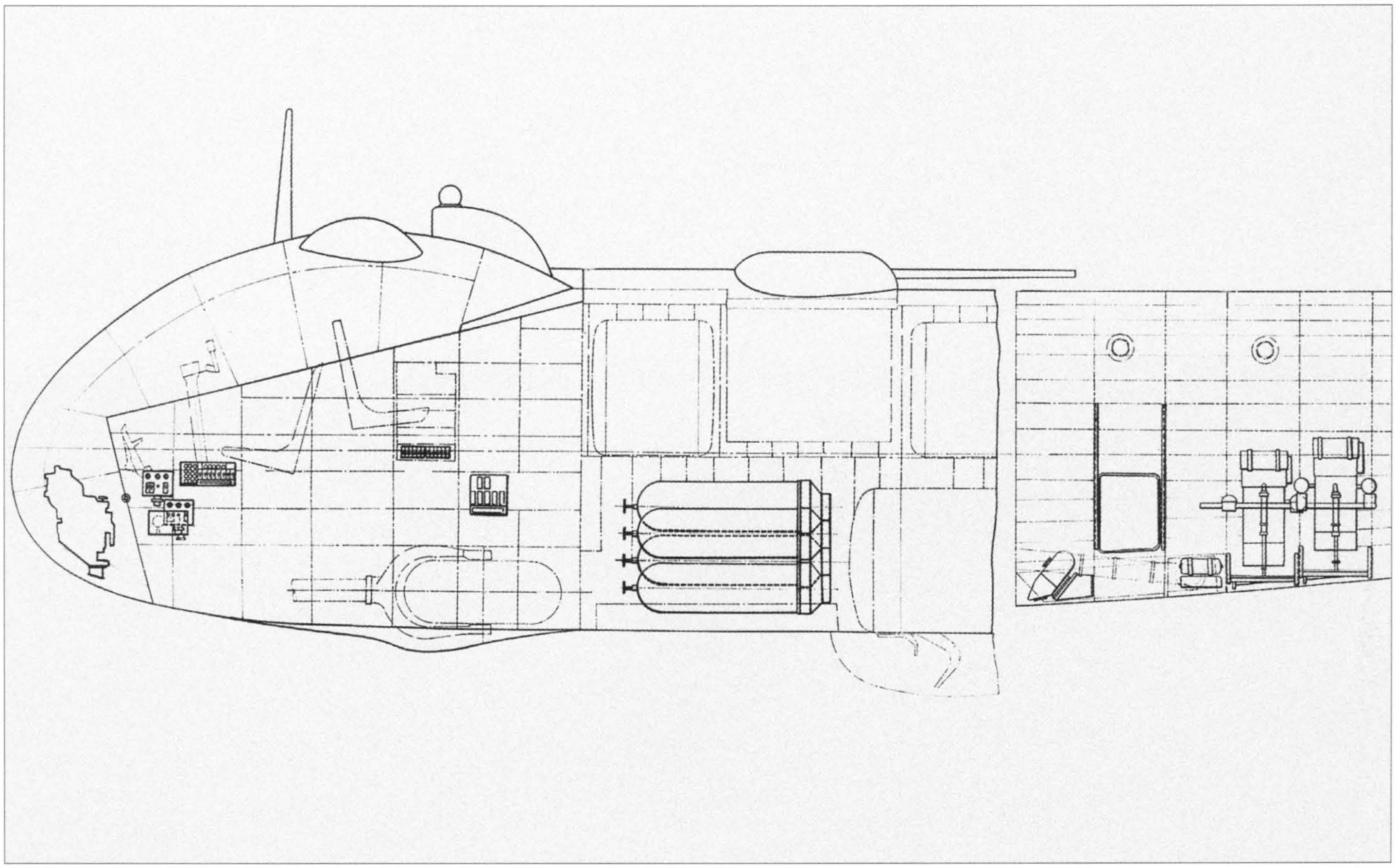
Above: An artist's impression of the '140-R' reconnaissance aircraft from the project documents. Note that the joints between the wings and the engine nacelles are depicted incorrectly.



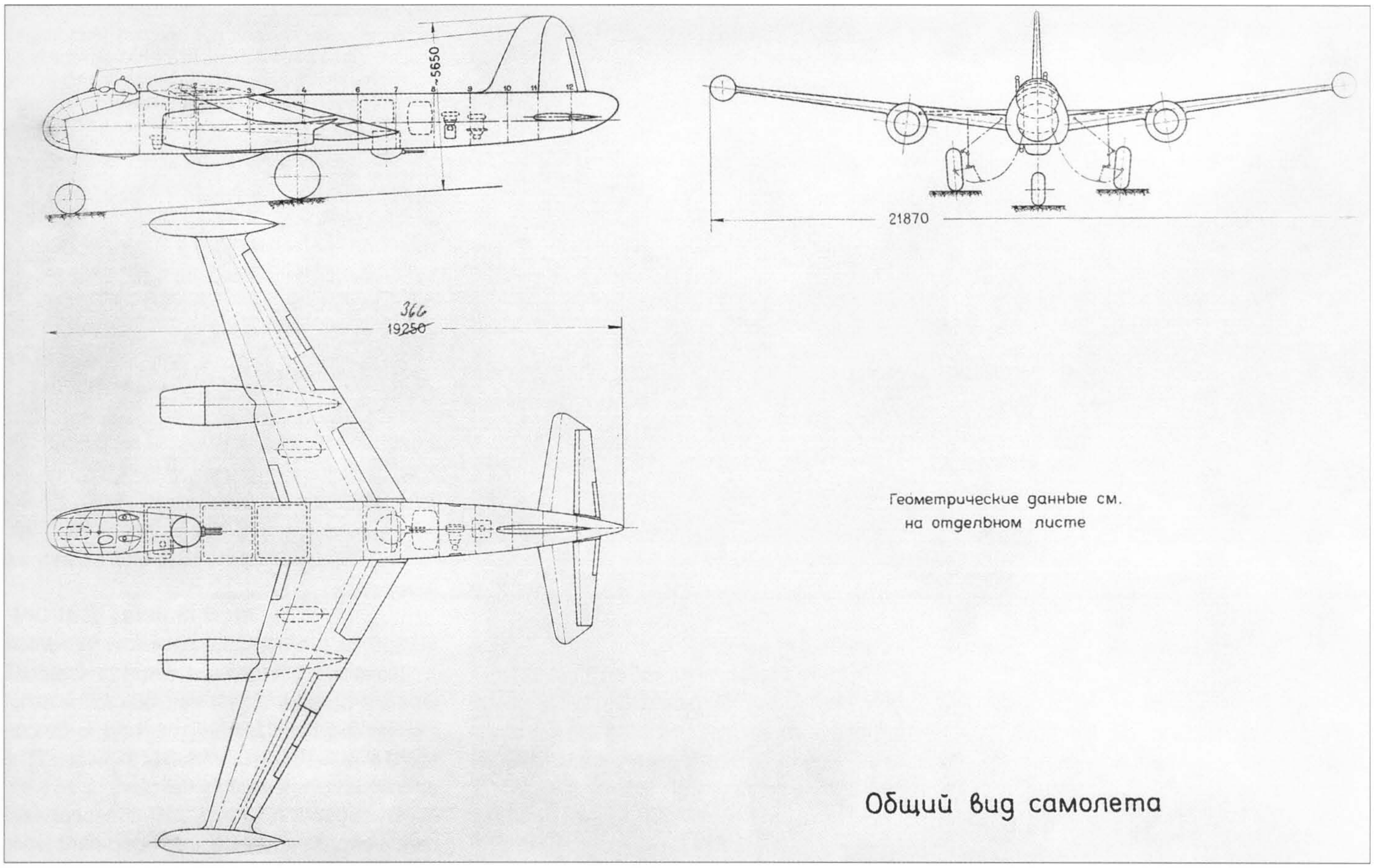
Above: The '140' prototype following conversion into the '140-R' reconnaissance aircraft. The new engine nacelles and tip tanks are clearly visible. Note the cannons in the dorsal turret and the large teardrop radome aft of the nose gear.



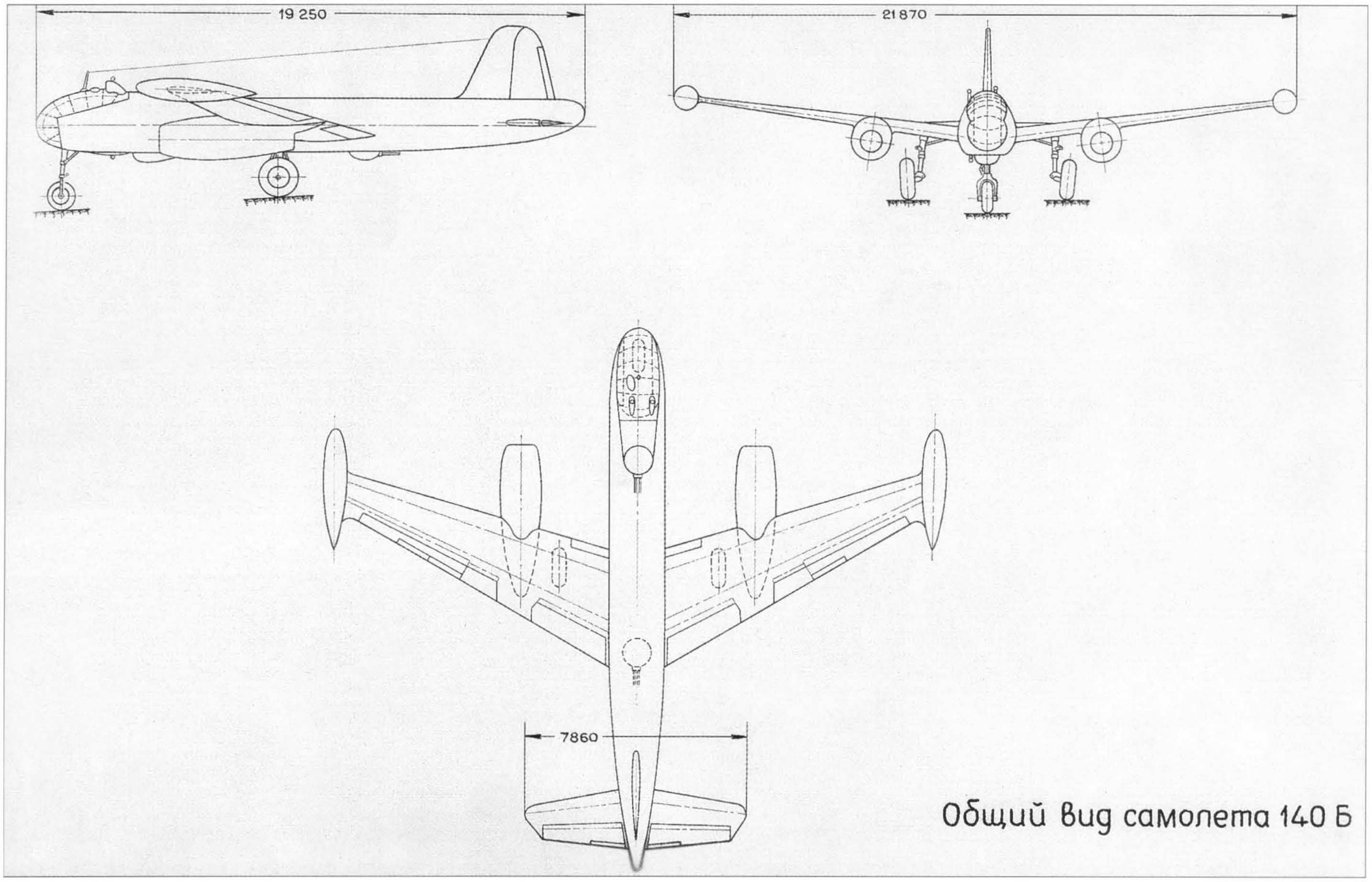
Above: A drawing illustrating the equipment fits of the '140-R' in day reconnaissance configuration with an AFA-33/20 camera in the forward bay plus AFA-33/75 (centre) and AFA-33/100 (rearmost) cameras in the rear fuselage.

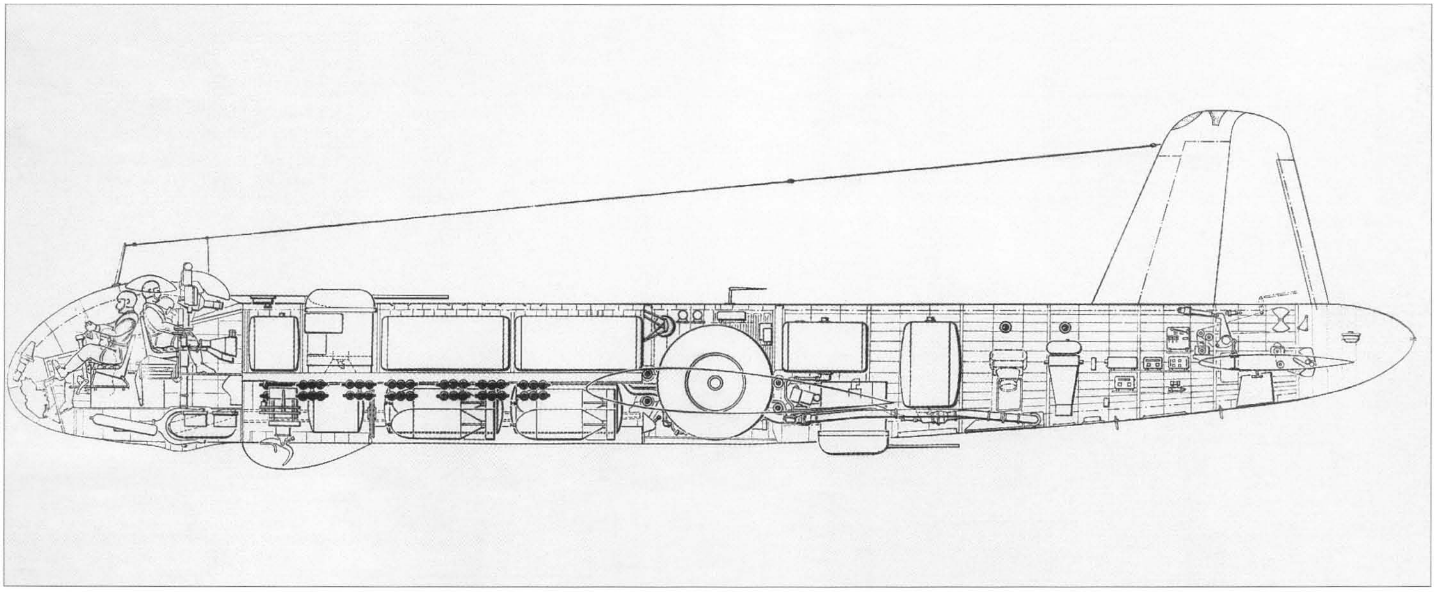


This drawing illustrates the night recce configuration of the '140-R'. The forward bay accommodates eight SAB-100/55 or SAB-100/75 and twelve FotAB-50/35 flare bombs; the rear fuselage houses a so-called 'selenium sight' (light detector) and two NAFA-3S/50 cameras.



Three-view drawings of the '140-R' reconnaissance aircraft (above) and the very similar '140-B' bomber (below). Note that the main gear units are cunningly designed to maximise the wheel track, the wheels being outboard of the oleos when extended but turning through 180° during retraction to stow vertically in the fuselage.





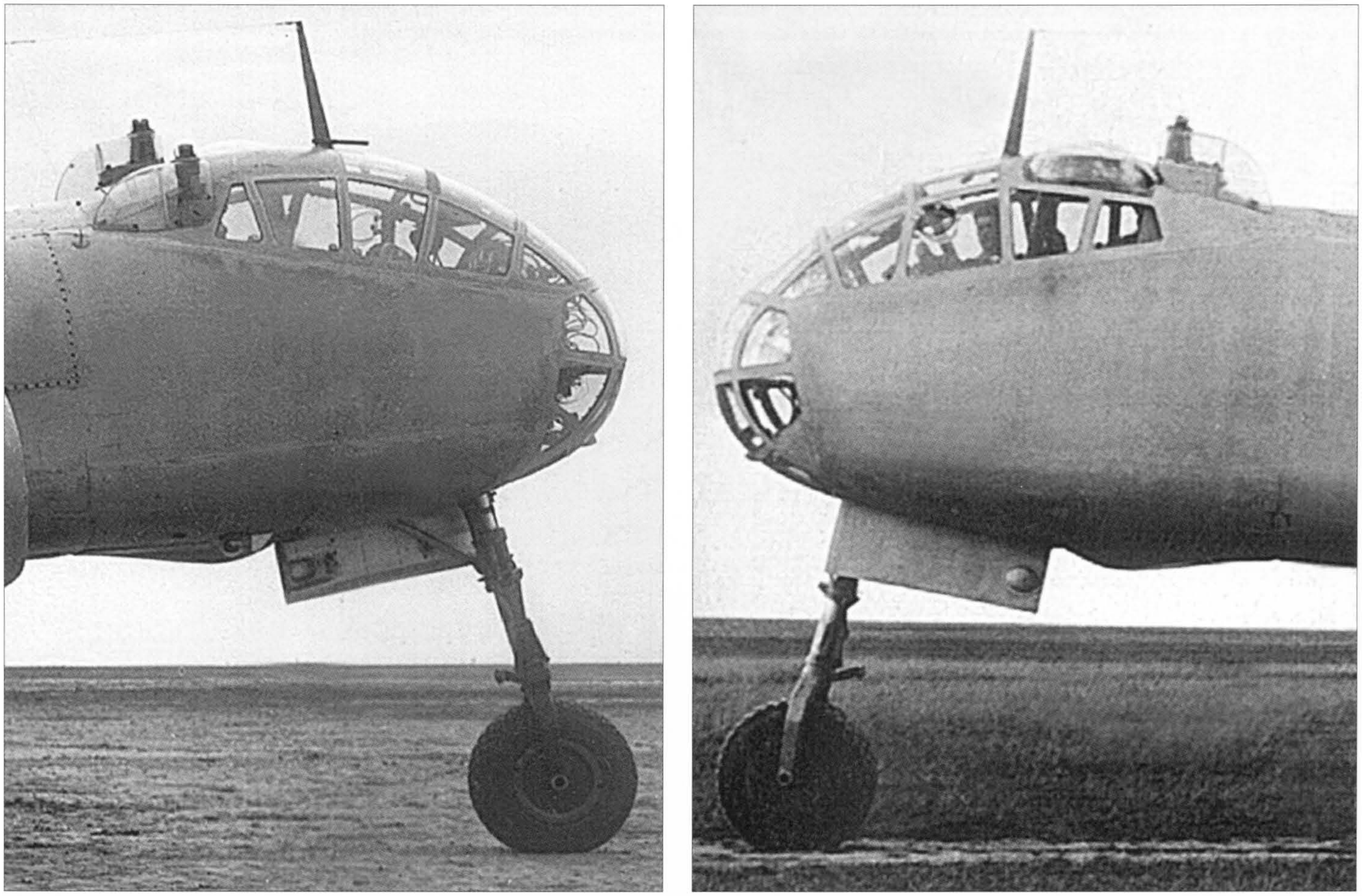
Above: A cutaway drawing of the '140-B' bomber, showing the navigation/bomb-aiming radar and the strike cameras in the rear fuselage.

ing twin 23-mm cannon with 150 rounds per gun. The dorsal turret was of the DT-V1 type, and the ventral turret of the DT-N1 type. The cannon were aimed with the help of periscopic gunsights, remote control of the turrets was electrically actuated. Should the gunner of the dorsal turret be killed or wounded, his turret could be switched over to the sight and control system of the ventral turret.

In 1949 a test airfield was built not far from GOZ No.1 in the village of Borki because the military were against admitting the Germans to the airfield in Tyoplyy Stan. It was in Borki that the manufacturer's tests of the '140-R' started in September 1949. As had been the case with the original '140', they were conducted by project test pilot I. Ye. Fyodorov.

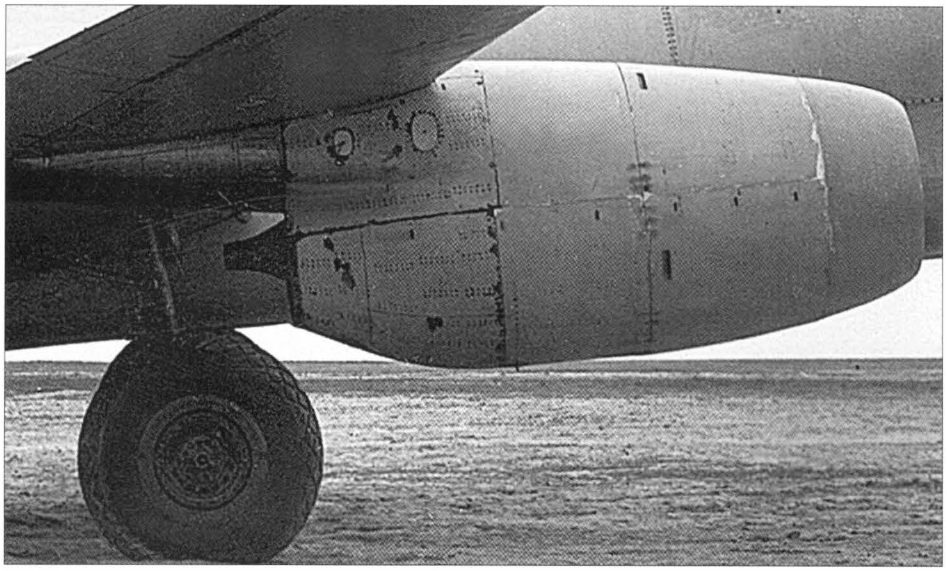
The first flight took place on 12th October. On 20th October the aircraft took to the air for the second time. Both flights had to be curtailed due to strong vibration of the wings. The aircraft was sent back to the plant.

During the first half of 1950 the reconnaissance aircraft underwent development work.



Two close-up views of the forward fuselage of the '140-R', showing the dorsal and ventral sights for the cannon barbettes (two above and one below).

Right: Close-up of the engine nacelles of the original '140' bomber. The engines were carried on almost horizontal pylons blended smoothly into the the nacelles and the wing structure. Note the cropped conical nozzle centrebody of the AM-TKRD-01 turbojet.



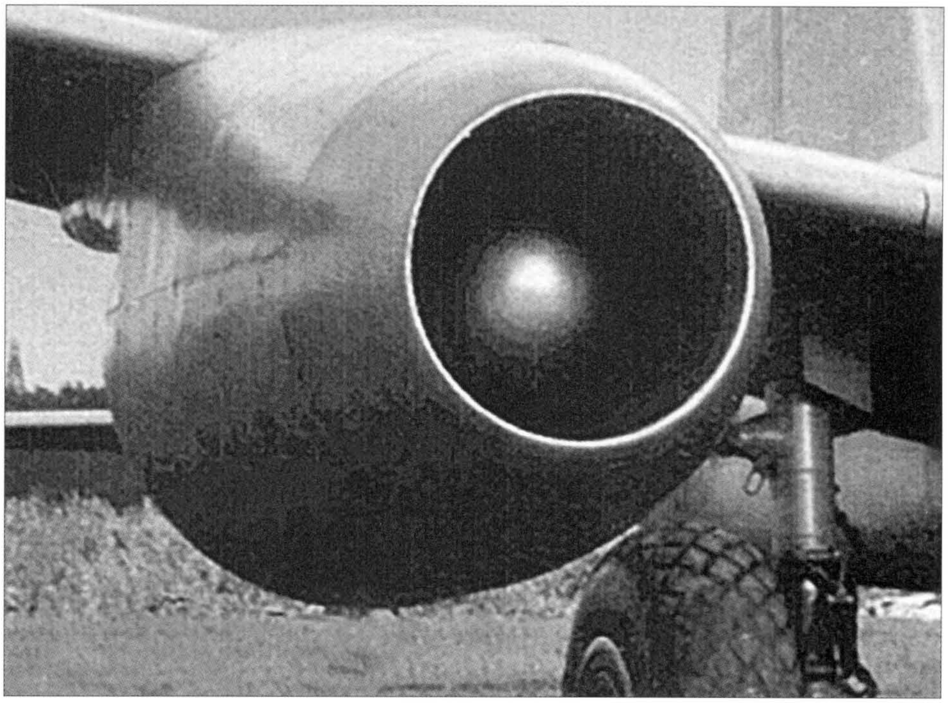
Two more flights were performed, the second of which took place on 24th March 1950. The vibrations of the wings persisted, and after that second flight the testing was suspended. TsAGI specialists joined in studying the problem. It was surmised that the flutter might have been caused by the wing-tip fuel tanks.

As a result of this situation, on 18th June (18th July, according to other sources) 1950 the Council of Ministers passed a new directive (No.2474-974), pursuant to which all work on the '140-R' aircraft was terminated and all the costs associated with this programme were to be written off by MAP.

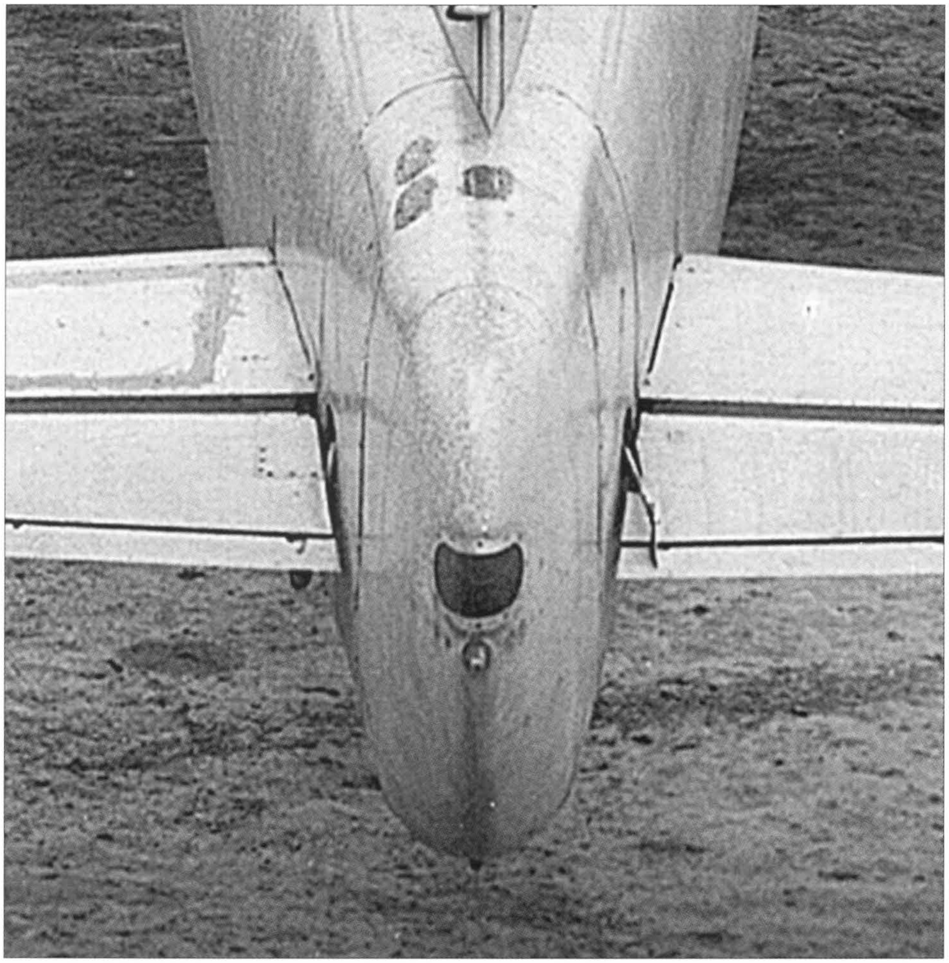
'140-B/R' tactical bomber/ reconnaissance aircraft

The work on a new version of the aircraft designated '140-B/R' started in 1949 in keeping with Council of Ministers' directive No.3568-1477 issued on 20th August. In Nazi Germany the '/R' suffix to an aircraft designation (eg, Messerschmitt Bf 110D-1/R2) stood for *Rüstsatz*, meaning that the aircraft had been upgraded with an additional equipment package; here, however, the B/R stood for *bombardi**rov**shchik-raz**ved**chik* (bomber/reconnaissance aircraft). The advanced development project was completed by 12th October; the following day it was submitted to MAP and to GK NII VVS.

Retaining the same layout and the same engines as the the '140-R' dedicated reconnaissance aircraft, the '140-B/R' differed from it primarily in mission equipment. Owing to the improvement of the defensive weapons' fire control system the crew was reduced to three persons, but he design AUW was increased to 26,112 kg (57,580 lb), this figure not including the weight of JATO rockets. The empty weight, compared to the reconnaissance version, was increased by more than 300 kg (660 lb) to 14,692 kg (32,395 lb) – primarily because of additional items of equipment. The design range of the '140-B/R' with a bomb load of 1,500 kg (3,310 lb) and a fuel load of 9,400 kg (20,730 lb) at altitudes between 8,900 and 12,700 m (29,190-41,650 ft) was 3,000 km (1,863 miles), the endurance being 4.7 hours. With a bomb load of 4,500 kg (9,920 lb) and a



Right and centre right: The engine nacelles of the '140' were designed for easy access to the engine, with large cowling panels allowing the AM-TKRD-01 to be exposed completely. The unpainted forward section of the port nacelle is the intake assembly fairing of the engine itself (the engine appears to have been replaced shortly before the picture was taken).



Above: The rear fuselage of the '140'.

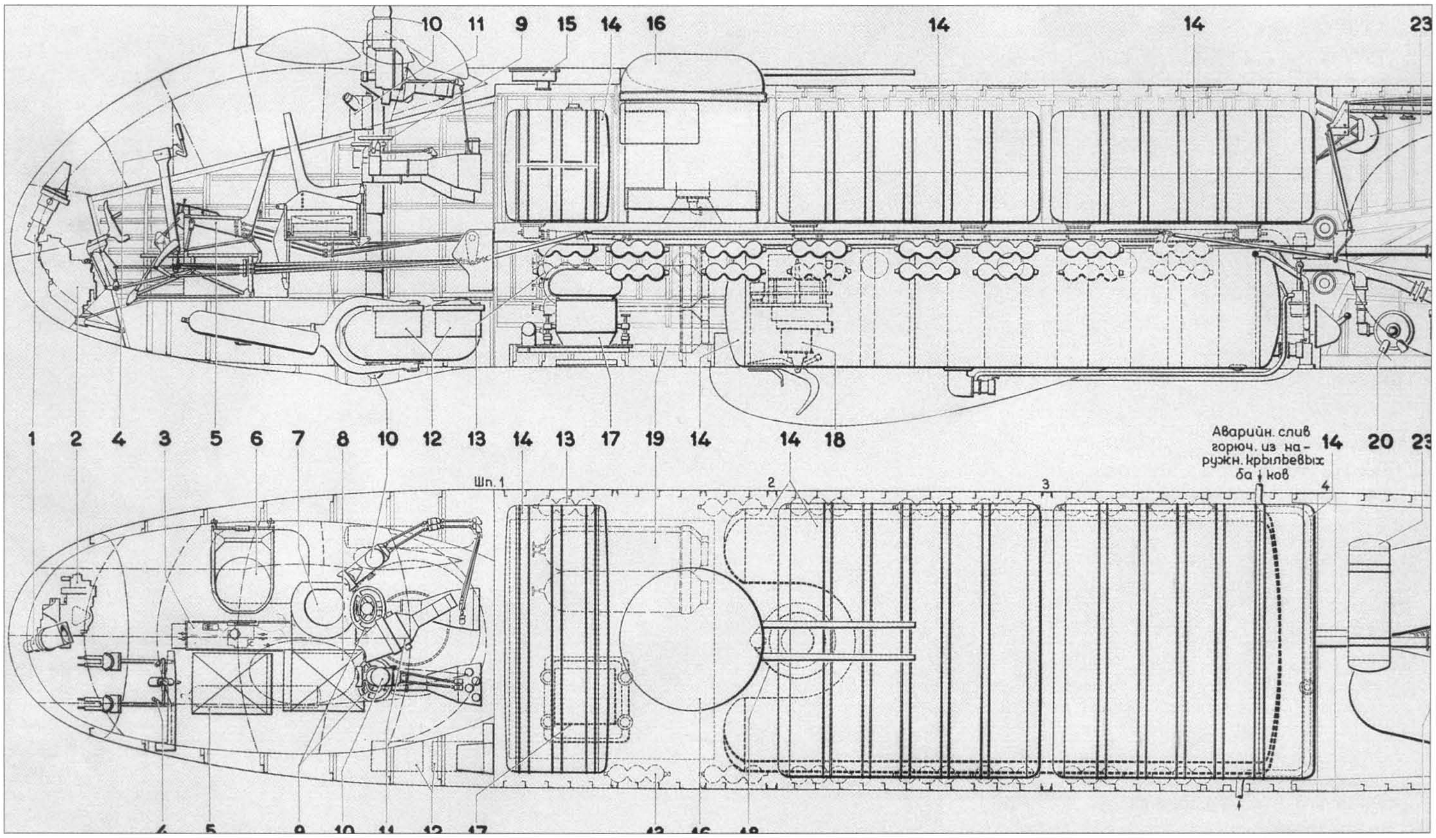
fuel load of 6,530 kg (14,400 lb) the range was 2,000 km (1,243 miles) and the endurance 3.0 hours. Maximum speed at 5,000 m (16,400 ft) was expected to reach 866 km/h (538 mph), while at sea level the bomber's top speed could not exceed 828 km/h (514 mph) because of limitations imposed with regard to dynamic pressure and structural strength up to the altitude of 1,700 m (5,570 ft).

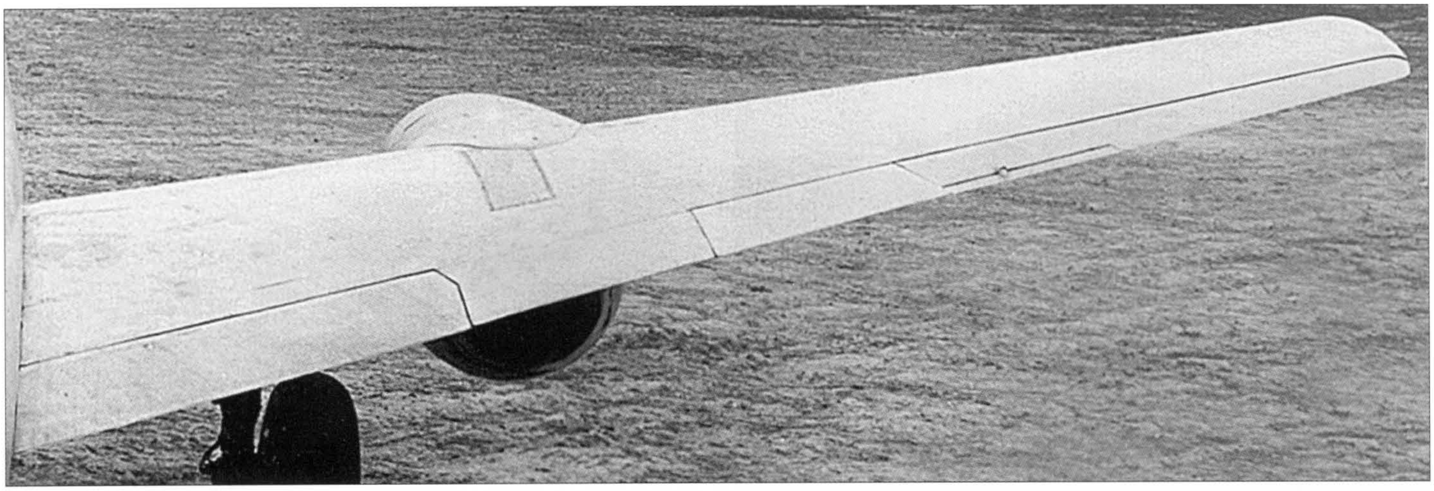
The service ceiling was 12,200 m (40,010 ft) at an all-up weight of 18,500 kg (40,790 lb); time to 5,000 m (16,400 ft) was expected to be 8.7 minutes. At a maximum AUW (26,112 kg/57,577 lb + four JATO rockets) the take-off run was estimated at 1,030 m (3,380 ft), the landing run at a landing weight of 16,500 kg (36,382 lb) should not exceed 1,350 m (4,430 ft) without using the brake parachute and 830 m (2,270 ft) with the parachute deployed.

The mock-up of the cockpit section was completed by 5th October, but on 8th October GK NII VVS issued a requirement for a full-scale mock-up of the aircraft. Construction of the latter took just over two weeks, being completed on 25th October. The mock-up was inspected by the State mock-up review commission which finished its work on 5th November. Detail drawings of the aircraft were almost completed by 1st November of that year.

During the first quarter of 1950 the last manufacturing drawings (100 sheets) were handed over to production engineers; the technical documentation for the aircraft had been compiled, comprising the technical description, flight manual, programmes and

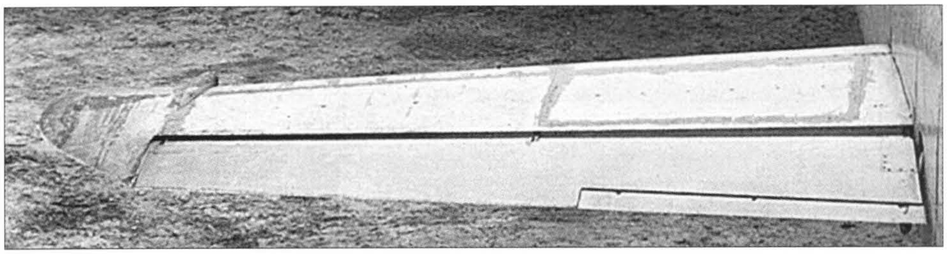
Below: A cutaway drawing of the forward fuselage of the '140-B/R'.

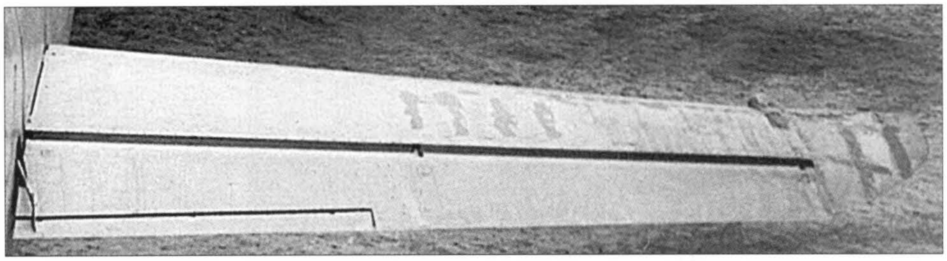




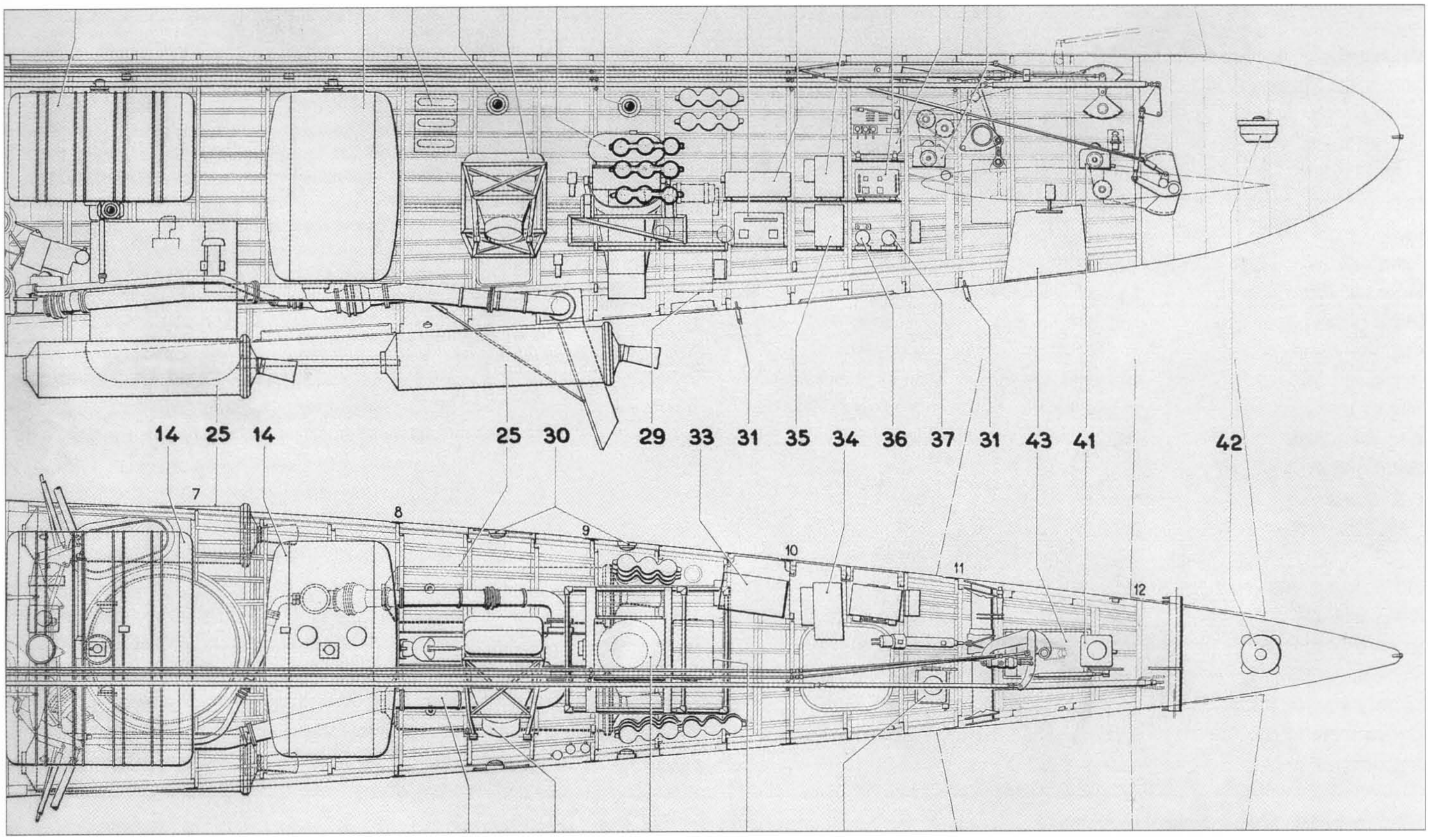
Above: The starboard wing of the '140', showing the two-section flaps inboard and outboard of the engine nacelle and the large one-piece aileron with a trim tab.

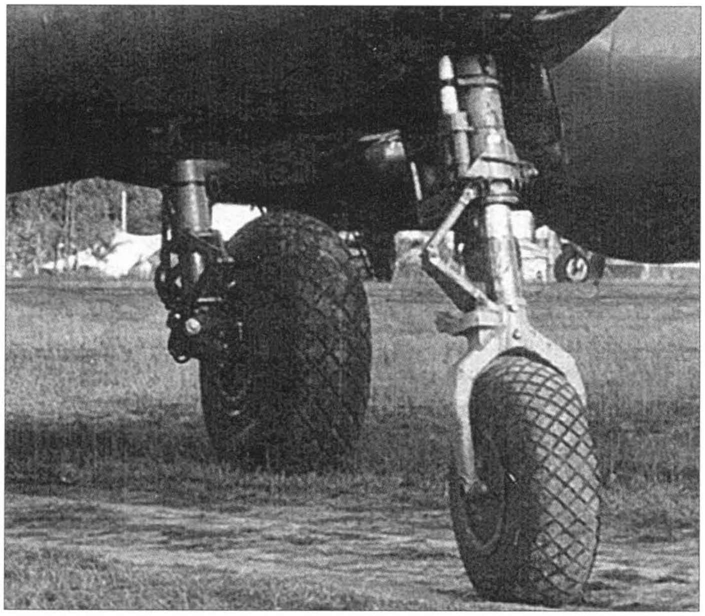
Right: The horizontal tail of the '140'. The significance of the lines on the stabilisers is unknown, but it is certainly not just mud.

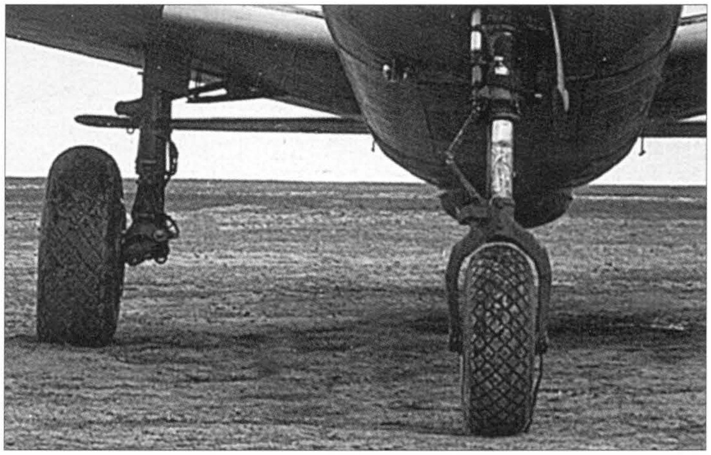


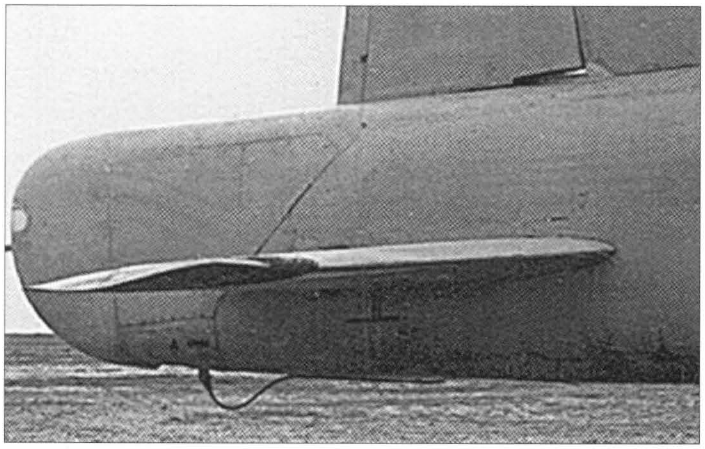


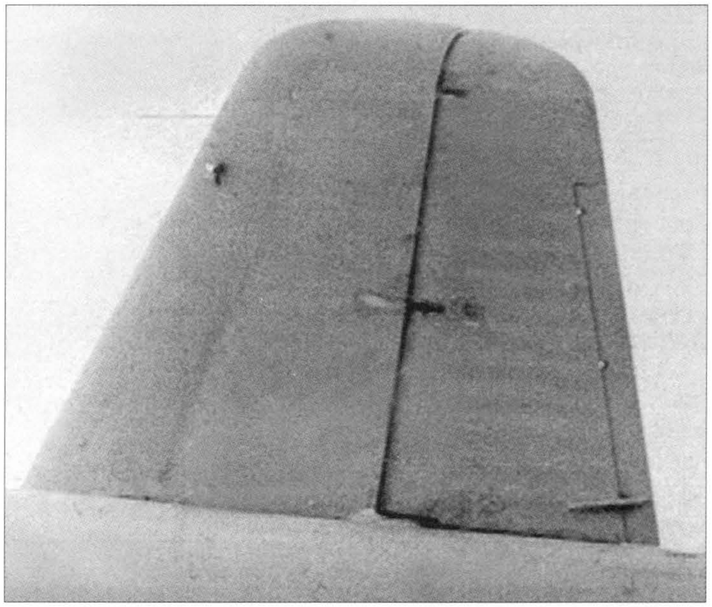
Below: A cutaway drawing of the rear fuselage of the '140-B/R'. Note the three JATO bottles arranged in V fashion around the ventral cannon barbette.











Top left: The nose landing gear unit of the '140'. Note the laterally mounted torque link.

Top right: The starboard main landing gear of the '140'. Note the hinge at the bottom allowing the wheel to swivel around the oleo during retraction.

Above: The vertical tail of the '140' appeared disproportionately small but evidently ensured adequate directional stability.

Above left: The rear fuselage of the '140'.

Comparative characteristics of the '140' aircraft versions

	'140'	'140-R' design data	'140-B/R' design data
Role	bomber	reconnaissance	bomber/reconnaissance
Crew	4	4	3
Powerplant	2 x AM-TKRD-01	2 x VK-1	2 x VK-1
Thrust, kgp (lbst)	2 x 3,300 (2 x 7,275)	2 x 2,700 (2 x 5,950)	2 x 2,700 (2 x 5,953)
Length overall	19.5 (63 ft 11¾ in)	19.25 m (63 ft 2 in)	19.36 m (63 ft 6¼ in)
Height on ground	5.7 (18 ft 8⅜ in)	5.65 (18 ft 6½ in)	5.65 m (18 ft 6½ in)
Wing span	19.4 m (63 ft 7¾ in)	21.87 m (71 ft 9 in)	21.0 m (68 ft 10¾ in)*
Wing area, m^2 (sq ft)	58 (624.36)	61 (656.66)	61 (656.66)
Wing sweep angle	–19°50'	–19°50'	–19°50'
Maximum speed, km/h (mph):			
at sea level	n.a.	785 (488)	828 (515)
at altitude, m (ft)	904/3,000 (563/9,840)	837/7,500 (520/24,600)	866/5,000 (538/16,400)
Landing speed, km/h (mph)	n.a.	205 (127)	205 (127)
Range, km (miles)	2,000 (1,243)	3,600 (2,237)	3,000 (1,865)
Service ceiling, m (ft)	11,700 (38,380)	14,100 (46,250)	12,200 (40,020)
Normal fuel load, kg (lb)	5,820 (12,830)	10,600 (23,370)	9,400 (20,730)
Normal bomb load, kg (lb)	1,500 (3,307)	–	1,500 (3,310)
Take-off weight, kg (lb)	23,000 (50,715)	25,543 (56,330)	26,100 (57,550)
Armament, mm	4 x 20	4 x 23	4 x 23

* Between the axes of the tip tanks

instructions for static tests and factory ground tests. Static tests of the aircraft's main assemblies and systems were conducted in April. However, there was no sequel: on 18th June 1950 all work on the '140-B/R' aircraft was also terminated pursuant to the already mentioned CofM directive No.2474-974.

By the time of issue of the directive closing down the programme the aircraft had been completed and had partially passed ground tests. After the unsuccessful testing of the '140-R' reconnaissance aircraft TsAGI specialists came to the conclusion that the use of forward-swept wings in aircraft construction was undesirable.

Chapter 5

Baade's Last Bombers

RB-2 short-range bomber project

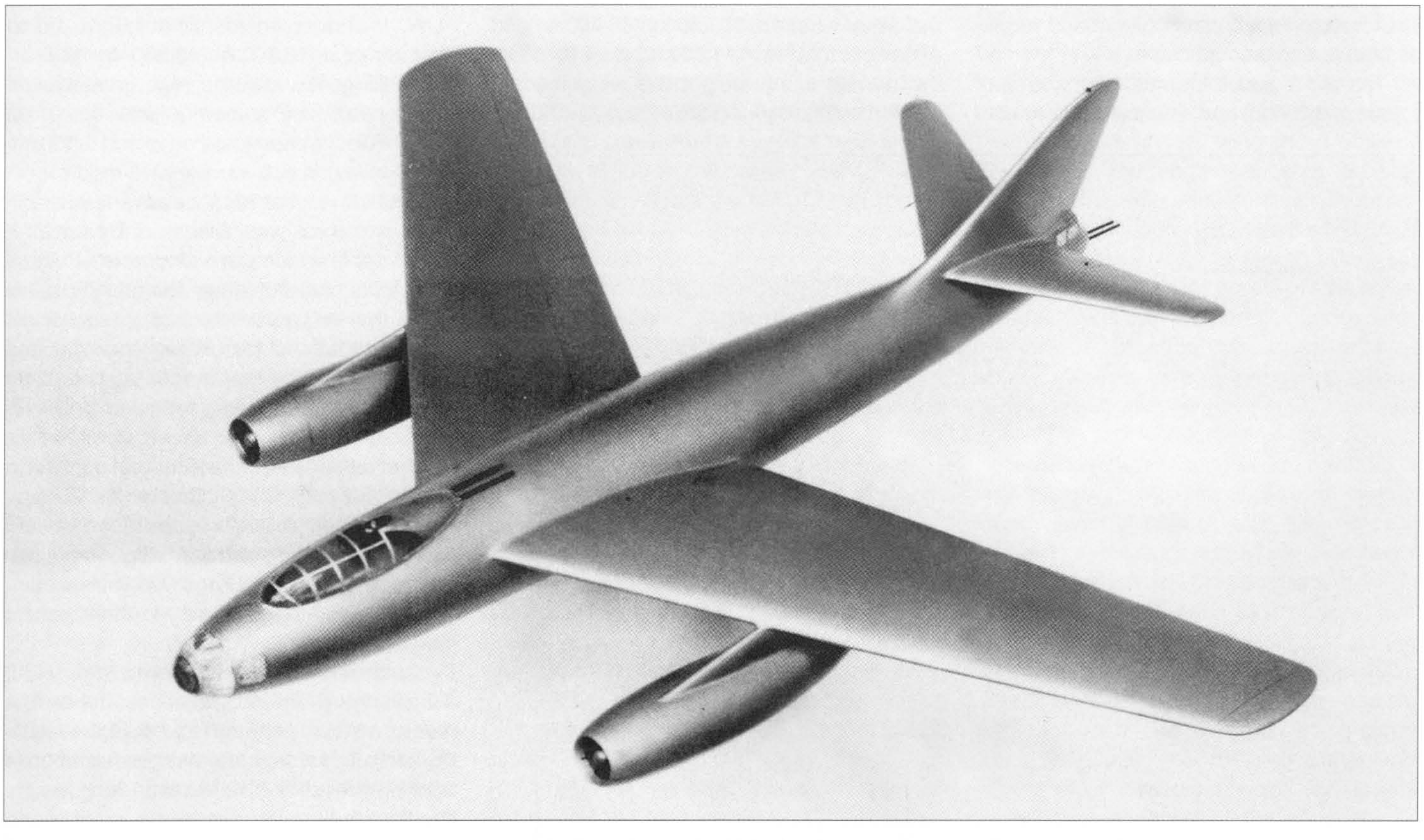
In the late spring of 1948 OKB-1 completed the preliminary design project of a short-range bomber designated RB-2 (*reak**tiv**nyy bombardi**rov**shchik* – jet bomber). The German designers bestowed the nickname *Riese* (giant) upon this aircraft because of its large size (by the day's standards). The specification for the new bomber was drawn up by the Long-Range Bomber Aviation top command and sent to S. N. Zhitkin, Director of MAP's 7th Main Directorate (some sources quote his last name as Shishkin), on 22nd May.

By then Semyon M. Alekseyev had been appointed head (or rather chief warden) of the OKB of the State Experimental Plant No.1. This well-known aircraft designer, the former aide of Semyon A. Lavochkin, was transferred to GOZ No.1 from the design bureau of the Gor'kiy aircraft factory No.21 (OKB-21), of which he had been Chief Designer. In this capacity he had developed a number of twin-jet fighters (two of them, the I-211 and I-215, had been built and tested) and the I-218 ground attack aircraft utilising an unconventional twin-boom layout with a piston engine driving contra-rotating pusher propellers and a tailwheel landing gear. Formally, however, Brunolf W. Baade remained Chief Designer of OKB-1, with Fritz Freytag and P. N. Obroobov as his deputies; Hans Wocke was chief of the PD section. Earlier Obroobov had been the aide of another well-known Soviet aircraft designer, Viktor N. Belyayev, who had created the highly unorthodox DB-LK bomber utilising the 'flying wing' layout. Lt. (sg) Vlasov was assigned to GOZ No.1 as the military quality control representative of the Soviet Air Force's Main Directorate of Experimental and Production Aviation Hardware.

Having been tasked with developing and building what eventually emerged as the '150' medium bomber (see below), OKB-1 headed by S. M. Alekseyev worked in close co-operation with TsAGI. The institute's chief specialists in aerodynamics and structural strength matters – S. A. Khristianovich, G. P. Svishchev, A. I. Makarevskiy, V. N. Belyayev and others – gave OKB-1 recommendations on various aspects of the bomber's design. Numerous enterprises and research establishments in the MAP system and within the frameworks of other ministries were involved in the development of the future bomber's systems and equipment.

The ADP was completed in July 1948 and submitted to Minister of Aircraft Industry Mikhail V. Khrunichev and the Director of GK NII VVS on 19th July. On 17th August 1948 the project was submitted for review to Minister of Defence Nikolay A. Bulganin.

According to the ADP the RB-2 short-range bomber was to feature shoulder-mounted wings swept back 38°30' at quarter-chord and swept tail surfaces; the wings utilised a carefully selected range of airfoils with a thickness/chord ratio of 9-11%. The engines – two Mikulin AM-TKRD-02 axial-flow turbojets rated at 4,000 kgp (8,820 lbst) for take-off and 3,600 kgp (7,940 lbst) for



A desktop model of the projected RB-2. The main features of the future '150' – the high-wing layout with large turbojet engines in pylon-mounted pods, the cigar-shaped fuselage with a fighter-type canopy, a glazed nose and a tail gunner's station and the bicycle landing gear – are already incorporated.

cruise flight or, alternatively, two Lyul'ka TR-3 axial-flow turbojets with take-off and cruise ratings of 5,000 and 4,000 kgp (11,020 and 8,820 lbst) respectively – were carried under the wings on forward-swept pylons. The normal fuel load was 7,000 kg (15,430 lb), increasing to 18,000 kg (39,680 lb) in overload (maximum take-off weight) configuration. The crew of five was accommodated in two pressurised compartments protected by 15-mm (0.59-in) armour plate, plus a bulletproof glass panel 120 mm (4.72 in) thick at the tail gunner's station; the armour offered protection against enemy fighter attacks in the rear hemisphere from within a ±15° cone relative to the aircraft's longitudinal axis. All five crew members were to be provided with ejection seats.

An interesting design feature of the new bomber was the novel bicycle landing gear with outrigger struts under the wingtips. The twin-wheel nose and main units retracting into the fuselage had identical 1,170 x 435 mm (46.0 x 17.12 in) wheels; the outrigger struts had single 600 x 200 mm (23.6 x 7.87 in) wheels. Equally interesting was the designers' idea that in the event of a wheels-up emergency landing the engine nacelles were to act in the manner of skids, absorbing the load.

The wings and tail unit were to be provided with a hot-air de-icing system. The RB-2 was to have powered controls with mechanical linkages and hydraulic actuators; the control system was to incorporate locking features intended to prevent control surface flutter. The forces on the control column and rudder pedals were to be adjustable.

The RB-2 had a normal bomb load of 1,500 kg (3,310 lb) and a typical bomb load of 3,000 kg (6,610 lb) – a single 3-ton bomb or a pair of 1.5-ton bombs; the maximum bomb load was 6,000 kg (13,230 lb), comprising twelve 500-kg (1,102-lb) bombs or eighteen 250-lb (551-lb) bombs. The defensive armament consisted of five 23-mm (.90 calibre) Nudelman/Suranov NS-23 cannons; the fixed forward-firing cannon had an ammunition supply of 100 rounds, while the paired cannons in the VDB-8 dorsal turret and the KDB-2A tail turret had 200 rpg each. (VDB = ***verkh****nyaya distantsi****on****no [oopravl****ya****yemaya]* ***bahsh****nya* – dorsal remote-controlled barbette; KDB = *kormo****va****ya distantsi****on****no [oopravl****ya****yemaya]* ***bahsh****nya* – rear remote-controlled barbette.)

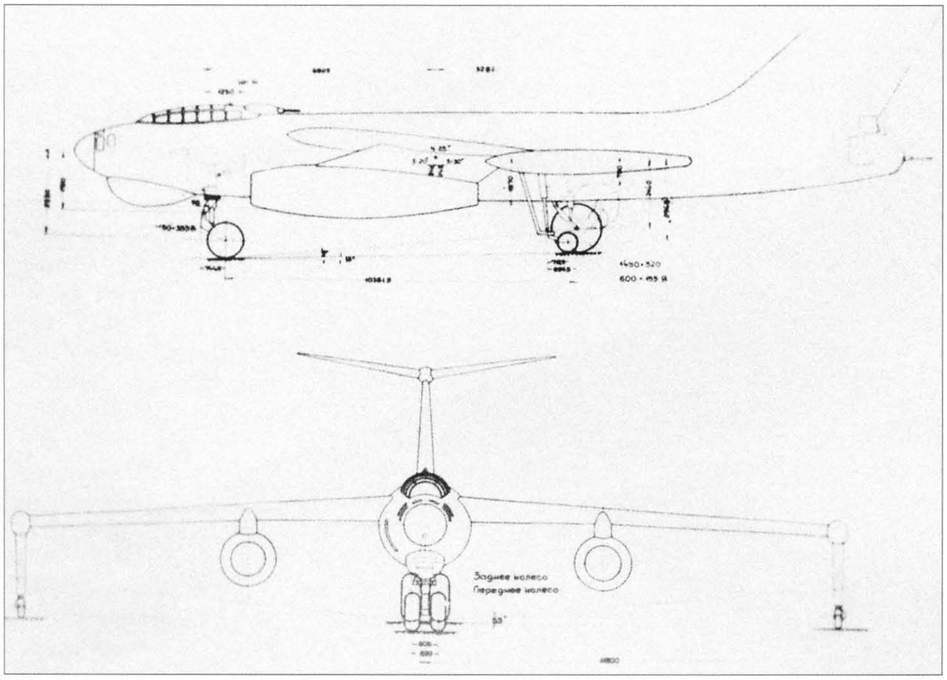
The RB-2 was to feature a comprehensive avionics suite comprising RSI-10 and RSB-5 transceivers, an SPU-5 intercom, an ARK-5 ADF, an RV-2 radio altimeter, a Rym-S navigation/attack radar ('rym' is a nautical term meaning 'lifting lug'), Bariy and Magniy IFF transponders and a Materik blind landing system. An AV-5 (aka EAP-45) electric autopilot would be used for maintaining course en route to the target. The crew would be provided with KP-14 breathing apparatus (*kislo****rod****nyy pri****bor*** – oxygen apparatus) and a complement of five or ten 4-litre (0.88 Imp gal) oxygen bottles, depending on the duration of the sortie. Provisions were made for an AFA-33/75 strike camera.

According to calculations the operating empty weight was to be 20,690 kg (45,610 lb); the TR-3 powered version was to have a normal all-up weight of 30,280 kg (66,750 lb) and a maximum AUW of 41,600 kg (91,710 lb). At the normal all-up weight the wing loading would be 273 kg/m² (55.97 lb/sq ft) and the power loading would be 3.03 kg/kgp (lb/lbst). With TR-3 engines the RB-2 was expected to attain a top speed of 955 km/h (593 mph) at 4,600 m (15,090 ft) and full military power, increasing to 1,000 km/h (621 mph) at 4,700 m (15,420 ft) with the engines at combat boost rating. Interestingly, the bomber was to be provided with airbrakes, a feature that would keep the landing speed with a 23,100-kg (50,925-lb) landing weight down to about 179 km/h (111 mph). The RB-2 was expected to climb to 6,000 m (19,685 ft) in 6.3 minutes and to 10,000 m (32,810 ft) in 14.4 minutes. The estimated rate of climb at sea level was 24 m/sec (4,720 ft/min), decreasing to 13.6 m/sec (2,680 ft/min) at 6,000 m. The service ceiling with an average all-up weight was estimated as 13,600 m (44,620 ft). The take-off run at full military power was 730 m (2,395 ft), with 920 m (3,020 ft) required to reach an altitude of 25 m (80 ft); at combat boost (contingency) rating increasing available thrust by 20% the take-off run and take-off distance was 580 and 710 m (1,900 and 2,330 ft) respectively. The landing run was not to exceed 530 m (1,740 ft).

The estimated range figures with a cruising speed of 810 km/h (503 mph) were as follows. With a fuel load of 7 tons (15,430 lb) and a 30,280-kg all-up weight (including 1.5 tons of bombs), the range at 13,700 m (44,950 ft) and at nominal power would be 2,000 km (1,240 miles), increasing to 2,700 km (1,675 miles) in economic cruise mode. With 18 tons (39,680 lb) of fuel and a 41,640-kg (91,800-lb) AUW, including an identical 1.5-ton bomb load, range at 12,300 m (40,350 ft) – the service ceiling was lower in high gross weight configuration, of course – was 4,700 km (2,920 miles) at nominal power and 5,300 km (3,290 miles) in economic cruise mode.

On 24th August 1948 the advanced development project was assessed by an MAP expert panel which gave a number of critical comments. Among other things, the panel noted that the parameters of the bomber's wings and tail unit should be recommended by TsAGI. Exactly one month later, on 24th September, the ADP was reviewed by GK NII VVS and received a go-ahead, again with a number of critical comments set forth in a special protocol. On 5th October GOZ-1 presented the full-scale mock-ups of the forward crew compartment and the tail gunner's station to a GK NII VVS mock-up review commission, which again approved them, except for a few details.

Soon afterwards, however, the RB-2 short-range bomber project underwent a redesign serious enough to regard the resulting aircraft as a separate design described in the next entry. The king is dead – long live the king!



A drawing of the '150' from the project documents; the main gear 'kneeling' feature is illustrated.

'150' medium bomber prototype

On 20th December 1948 the State Experimental Plant No.1 (GOZ No.1) received a set of recommendations from TsAGI concerning the general arrangement and internal layout of the projected RB-2 bomber, as well as wing and tail unit design. These were followed on 19th February by more recommendations, this time concerning the structural loads with regard to the bicycle landing gear designed by OKB-1. On 20th February OKB-1 issued the first drawings for the jigs and tooling to be used for prototype construction, followed on 10th March by the first blueprints for the aircraft itself.

The full-scale mock-up of the RB-2 was completed on 20th March 1949; by then the bomber had received the in-house designation 'aircraft 150' (or simply '150'). On 11th April the mock-up was presented to the State mock-up review commission which endorsed it, accepting the manufacturer's performance estimates but requesting that certain changes be made. Yet, on 20th May OKB-1 was instructed by the ministry to stop all work on the TR-3 powered version and set about redesigning the '150' to take the Mikulin AMRD-04 axial-flow turbojets.

As already mentioned, the bomber's general arrangement and internal layout were developed by a team headed by the German engineer Hans Wocke, with I. L. Makarov as his deputy. The work proceeded in co-operation with the other sections of OKB-1, notably the aerodynamics section headed by engineer L. B. Balkind.

The work progressed quickly, in harmony and without any major difficulties. The advanced development project incorporated a number of clever design solutions. The fuselage of the '150' was built in three sections. The entire forward fuselage section was a pressurised compartment accommodating three of the four crew members – the captain, the co-pilot/radar operator (who also performed navigation and bomb-aiming tasks) and the dorsal gunner who aimed the remote-controlled dorsal barbette by means of a revolving periscopic sight. The crew compartment was protected from below by armour slabs. The rear fuselage represented another pressurised compartment for the tail gunner. The centre fuselage incorporated the bomb bay which was large enough to accommodate up to 6,000 kg (13,230 lb) of bombs; it could also house long-range fuel tanks.

The wings swept back 35° at quarter-chord were a monobloc (one-piece) structure with skin panels supported by corrugated internal stiffeners. The wing centre section accommodated integral fuel tanks. The trailing edge was occupied by two-section flaps (there were no leading-edge devices) and three-section ailerons, while the rudder and elevators were likewise divided into two and three sections respectively. The division of the flaps and control surfaces into sections was a measure aimed at increasing combat survivability, preventing them from being disabled by a single hit.

Unlike the earlier RB-2 project, the '150' featured a T-tail – a feature subsequently used on many commercial and military aircraft both in the Soviet Union and abroad. Unusually, the horizontal tail had pronounced dihedral.

The unusual design features deserve a more detailed description. The flight control system was particularly noteworthy, since it dispensed with the hydraulic actuators which had become obligatory even for fighters, to say nothing of heavy aircraft, by the early 1950s. The traditional control cables, push-pull rods and bellcranks were replaced by torsional shafts driven by individual electric motors via coarse-pitch screw-and-nut pairs; the electric motors were located in close proximity to the flaps and control surfaces. Given the large size of the '150', the power supply cables for the individual electric actuators were easier to route through the bomber's airframe than traditional mechanical control runs or hydraulic lines.

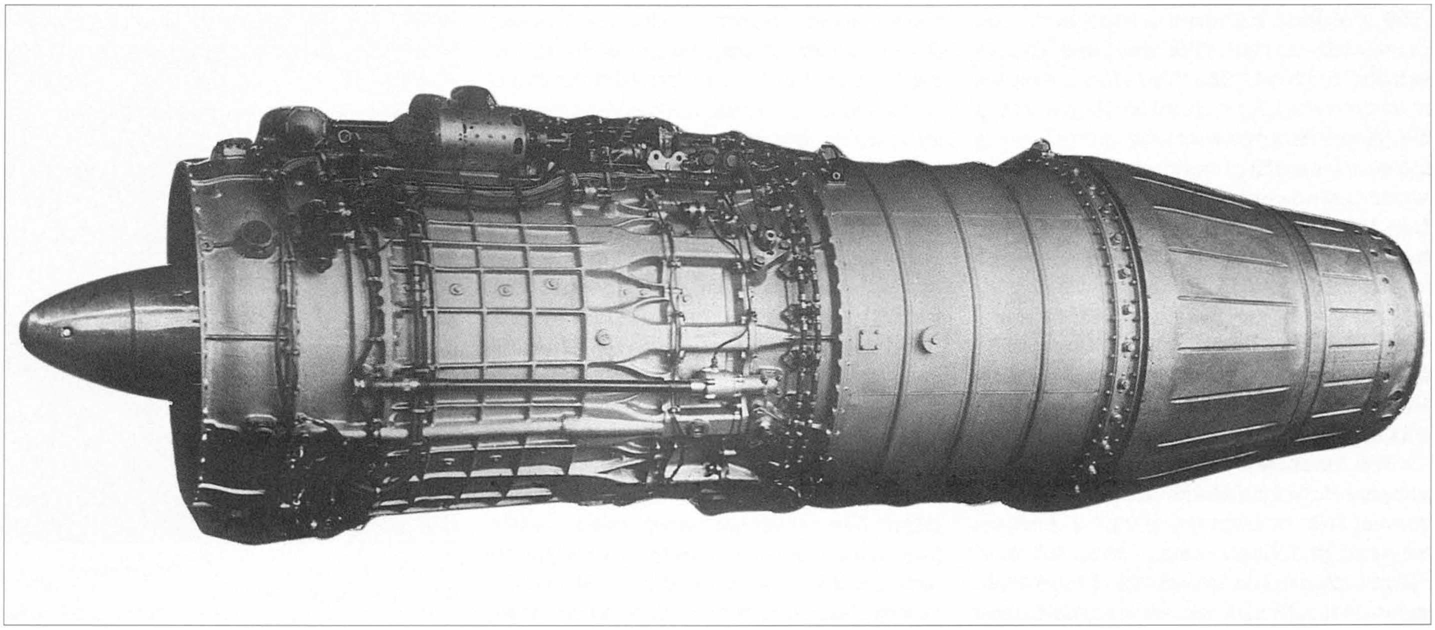
The proposed electromechanical controls were greeted enthusiastically by some and with deep mistrust by others. The sceptics claimed that the friction in the screw-and-nut pairs would be insurmountable; they pointed out that manufacturing and assembling the screws and screw sockets would be difficult. Some people questioned the reliability of the electric circuit of the 'pilot to generator to electric motor to control surface' drive train. This time the aircraft's designers needed not only to convince the sceptics but first and foremost to see for themselves that their own ideas worked. Since the likes of this control system had not been seen before, the system underwent lengthy and rigorous testing – both on a ground rig ('iron bird', in Boeing terminology) and on a Junkers Ju 388L bomber, a captured example of which was used by GOZ No.1 as a control system testbed.

A matter of grave concern was that in the event of a dual engine failure all engine-driven generators would become inoperative, putting the flight control system out of action. To preclude this possibility the engineers had to incorporate an emergency generator driven by a ram-air turbine (RAT) with multiple blades; the generator was located in a small streamlined housing and was powerful enough to cater for the needs of both the control system and the cockpit instrumentation in night flight conditions when additional power is required for the lighting equipment.

A small test rig was built to verify the control system mechanics, emulating the cockpit controls and featuring the control surface actuators (less electric motors and wiring). The fears about excessive friction in the screw-and-nut pairs were allayed immediately; as the electrics engineers set to work adapting the electrical part of the system to the airframe, the technologists opposing the system threw up the sponge and gave the go-ahead. The discussions petered out and the unconventional control system was adopted for the new bomber.

Semyon M. Alekseyev, head of OKB-1 which developed the RB-2 and the '150'.

The idea of installing the engines on underwing pylons was floated by the engineers of Arkhip M. Lyul'ka's OKB-165 who had gained some experience with a similar engine installation on the Ilyushin IL-22 bomber prototype. In the latter case (and on the '140' bomber prototype), however, the turbojets were carried on horizontal pylons installed in line with the wing chord, while on the '140-R' the engine nacelles adhered directly to the wing undersurface without any pylons at all. Thus the '150' was the first Soviet aircraft to feature 'real' (ie, swept) pylons setting the engine nacelles apart from the wings. This feature precluded harmful aerodynamic interference between the wings and the engine nacelles, improving the wing aerodynamics. In practice this gave a major increase in wing lift at the expense of only a minor increase in drag as compared to the flush-fitting nacelles; the result was a marked improvement in lift/drag ratio and hence in range. The length of the pylons (and hence the distance between the nacelles and wings) was limited by the need to ensure an adequate distance between the air intakes and the ground in order to prevent foreign object ingestion. The pylon sweep (79°30') was calculated in such a way as to provide the optimum distance between the engine's centre of gravity and the wing's torsional rigidity axis. Being located ahead of the wing leading edge, the 1,300-kg (2,865-lb) engines acted

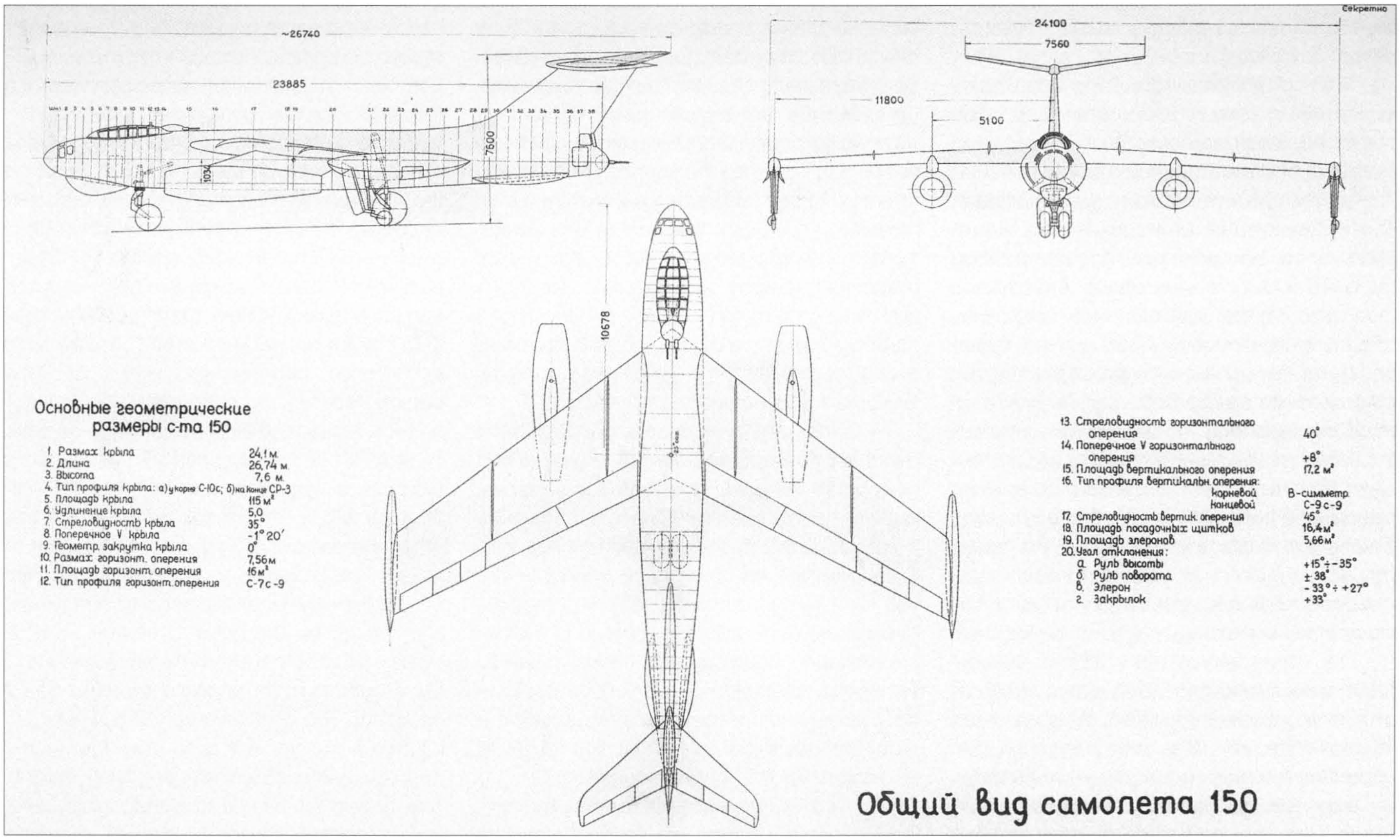


Above: The Lyul'ka TR-3A (AL-5) turbojet which, after much deliberation, was selected to power the '150'.

as anti-flutter weights, effectively damping the wings' self-oscillations caused by bending and torsional loads.

Like its precursor, the '150' was designed with a bicycle landing gear featuring twin-wheel nose and main units which absorbed 40% and 60% of the aircraft's weight respectively. The nose unit was steerable, steering being effected by the rudder pedals. All units retracted aft. The single-wheel outrigger struts retracted into cigar-shaped wingtip fairings; when extended, the outrigger wheels were in line with those of the main gear unit. The landing gear was hydraulically operated, with a feedback feature; unusually, the hydraulic rams used for gear retraction/extension doubled as the oleo struts (shock absorbers).

It should be noted that part of OKB-1's design staff (which had previously been engaged in developing the flying boats of Igor' V. Chetverikov), as well as the interned German specialists and many MAP employees who were involved in the '150' programme in one way or another, were opposed to the bicycle landing gear, considering it to be unsuitable for such a heavy aircraft. The unfortunate experience Aleksandr S. Yakovlev's OKB-115 had with the much smaller Yak-50 experimental fighter (the first



Основные геометрические размеры с-та 150

1. Размах крыла	24,1 м.
2. Длина	26,74 м.
3. Высота	7,6 м.
4. Тип профиля крыла: а) у корня С-10с; б) на конце СР-3	
5. Площадь крыла	115 м²
6. Удлинение крыла	5,0
7. Стреловидность крыла	35°
8. Поперечное V крыла	-1°20′
9. Геометр. закрутка крыла	0°
10. Размах горизонт. оперения	7,56 м
11. Площадь горизонт. оперения	16 м²
12. Тип профиля горизонт. оперения	С-7с-9

13. Стреловидность горизонтального оперения	40°
14. Поперечное V горизонтального оперения	+8°
15. Площадь вертикального оперения	17,2 м²
16. Тип профиля вертикальн. оперения:	
корневой	В-симметр.
концевой	С-9с-9
17. Стреловидность вертик. оперения	45°
18. Площадь посадочных щитков	16,4 м²
19. Площадь элеронов	5,66 м²
20. Угол отклонения:	
а. Руль высоты	+15° ÷ -35°
б. Руль поворота	± 38°
в. Элерон	-33° ÷ +27°
г. Закрылок	+33°

A three-view drawing of the '150' in its definitive form (as actually built). The location of the fuselage frames is indicated on the side view; note how the spacing of the frames increases in the area of the bomb bay.

aircraft to bear this designation), which was literally blown off the runway by crosswinds, served only to strengthen these misgivings.

The bicycle landing gear had its strengths and weaknesses. The advantages which it offered were easier removal and installation of complete engine nacelles during engine changes, a simpler nacelle structure which did not incorporate a mainwheel well and main gear attachment points, keeping the mainwheel tyres well away from the hot engine jetpipes, the heat from which would otherwise shorten the tyres' service life, the possibility to enlarge the wingtip fairings used for outrigger gear stowage and utilise them as extra fuel tanks, and the reduction of structural loads at the wing/fuselage joint. The handicaps, on the other hand, were higher drag and increased vibrations as compared to a conventional tricycle undercarriage, the inordinately large dimensions of the landing gear and increased structural weight, a more complicated landing gear control system with long control runs and/or hydraulic piping (which again added to structural weight), operational inconveniences, including more complicated taxying (especially in the case of large aircraft which required very wide taxiways), and higher manufacturing costs and labour intensity.

The factor which tipped the scales in favour of the bicycle landing gear was undoubtedly the leader of OKB-1, Semyon M. Alekseyev, who successfully tested this landing gear arrangement on his I-215D experimental twinjet fighter. The original arrangement with the outrigger struts under the engine nacelles was abandoned in order to use the wingtip fairings as anti-flutter weights. At Brunolf Baade's suggestion the main gear unit was designed to incorporate a 'kneeling' feature which increased the angle of attack on take-off by 3°, shortening the take-off run.

In 1949-51 the OKB undertook research and test work under the '150' programme. Among other things, a hydraulic elevator servo actuator developed for the '150' was tested on the Ju 388L; this testbed was known at GOZ No.1 as *iz**del**iye* (product) 145 or 'aircraft 145'. Concurrently the bicycle landing gear was verified on the I-215D which also had an alternative designation at the plant (*izdeliye* 155). (It should be noted that the first prototype I-215 had a conventional tricycle undercarriage with twin-wheel main units retracting inwards into the fuselage. It was after Alekseyev's transfer to GOZ No.1 that he decided to convert the incomplete second prototype (hence the D for *doob**lyor*** – lit. 'understudy', which was the Soviet term for 'second prototype' until the mid-1960s) into a bicycle landing gear testbed as part of the effort to create the heavier '150' bomber.) Apart from the tests involving real aircraft, a lot of wind tunnel research was done, using both the plant's own wind tunnel and the TsAGI T-102 wind tunnel. The manufacture of the '150' prototype's airframe and systems components began in 1950 concurrently with the continuing test and research effort.

By 1st June 1949 OKB-1 had issued nearly 1,500 blueprints for the bomber's airframe components and about 500 more for equipment items, and the experimental templates for the wings and fuselage had been manufactured. 30% of the airframe components intended for static testing had been completed and these had undergone 70% of their test cycles.

In early June 1949 the plant received a top-priority assignment requiring it to convert the '140' bomber prototype into the '140-R' photo reconnaissance aircraft in accordance with the aforementioned Council of Ministers' directive No.1886-696 of 14th May 1949. Hence the work on the '150' prototype had to be suspended, resuming in the second half of July. Before that, on 6th June, MAP went back on its earlier requirements and reverted to the Lyul'ka TR-3A as the powerplant of the '150', eliminating the Mikulin AMRD-04 engines from the programme; hence the parameters had to be calculated anew to match the smaller engines. On 4th July GOZ No.1 received Part 1 of the specific operational requirement (SOR) for the '150' bomber which had been endorsed by the Soviet Air Force Commander-in-Chief on 14th June; the duly signed protocol of acceptance for the full-scale mock-up of the TR-3 powered '150' followed four days later (on 8th July).

During the second half of July, all of August and the early days of September OKB-1 issued about 1,800 blueprints for various airframe components (wing spars, wing leading-edge fairings, flaps, ailerons, wingtip fairings, reinforced wing ribs, forward and centre fuselage frames, the principal components of the nose and main landing gear units and so on) Within the same time frame Shop 11 of GOZ No.1 completed fore than 1,000 parts of the wings' and fuselage's internal structure, while Shop 14 erected the assembly jigs for the flaps, wing leading-edge fairings, wing spars and wingtip fairings. It was a hectic time for F. P. Voznesenskiy, the plant's Chief Engineer.

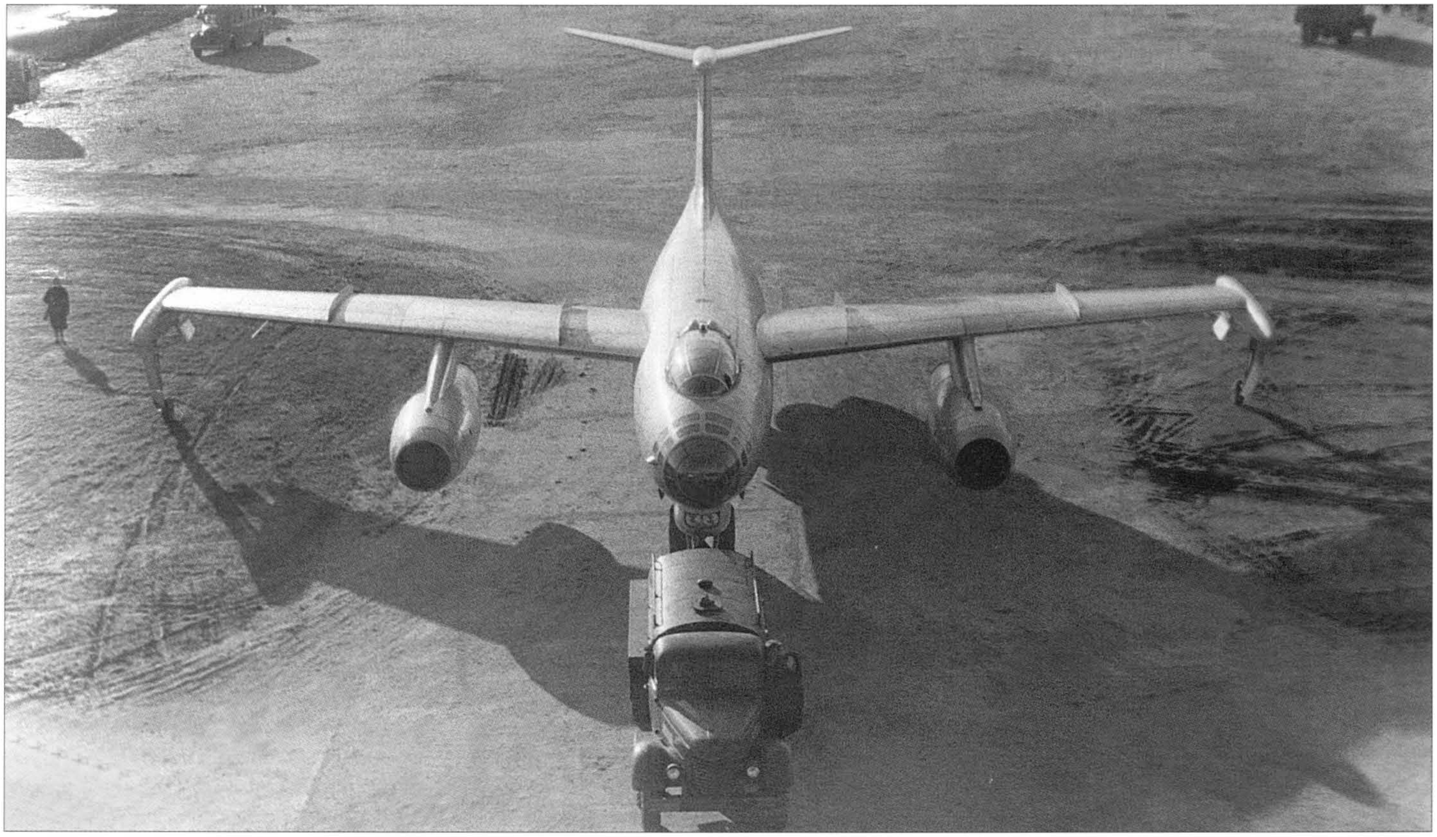
In early September the work on the '150' bomber had to be halted again due to another crash programme calling for the development of the '140-B/R' bomber/reconnaissance aircraft. Some of OKB-1's design teams were

Performance of the '150' bomber (manufacturer's estimates)

Powerplant	2 x Lyul'ka TR-3A	2 x Mikulin AMRD-04
Empty weight, kg (lb)	24,400 (53,790)	26,300 (57,980)
Normal all-up weight, kg (lb)	35,760 (78,835)	38,120 (84,040)
Maximum all-up weight, kg (lb)	44,760 (98,680)	51,620 (113,800)
Bomb load, kg (lb):		
at normal AUW	1,500-6,000 (3,310-13,230)	1,500-6,000 (3,310-13,230)
at maximum AUW	1,500 (3,310)	1,500 (3,310)
Fuel load, kg (lb):		
at normal AUW	9,000 (19,840)	9,500 (20,940)
at maximum AUW with drop tanks	18,000 (39,680)	23,000 (50,700)
Maximum speed, km/h (mph)	970 (602)	1,050 (652)
at altitude, m (ft)	4,200 (13,780)	5,600 (18,370)
Range with normal AUW, km (miles)	2,400 (1,490)	2,400 (1,490)
at altitude, m (ft)	13,000 (42,650)	14,000 (45,930)
Range with maximum AUW, km (miles)	4,500 (2,795)	5,000 (3,100)
Take-off run, m (ft):		
at normal AUW without JATO boosters	1,100-1,200 (3,610-3,940)	730 (2,400)
at maximum AUW without JATO boosters	1,950 (6,400)	1,450 (4,760)
at maximum AUW with four JATO boosters	1,200 (3,940)	950 (3,120)

Estimated range of the '150' bomber at a cruising speed of 800 km/h (496 mph)

AUW, kg (lb)	Range, km (miles)	Bomb load, kg (lb)	Fuel load, kg (lb)	Service ceiling, m (ft)
38,000 (83,770)	2,400 (1,490)	1,500 (3,310)	9,000 (19,840)	11,000-13,000 (36,090-42,650)
38,000 (83,770)	1,900 (1,180)	3,000 (6,610)	7,500 (16,530)	11,000-13,000 (36,090-42,650)
38,000 (83,770)	1,500 (930)	4,500 (9,920)	6,000 (13,230)	11,000-13,000 (36,090-42,650)
47,000 (103,615)	4,500 (2,795)	1,500 (3,310)	18,000 (39,680)	11,000-13,000 (36,090-42,650)
47,000 (103,615)	4,000 (2,480)	3,000 (6,610)	16,500 (36,375)	11,000-13,000 (36,090-42,650)
47,000 (103,615)	3,500 (2,170)	4,500 (9,920)	15,000 (33,070)	11,000-13,000 (36,090-42,650)
47,000 (103,615)	3,100 (1,925)	6,000 (13,230)	13,500 (29,760)	11,000-13,000 (36,090-42,650)



A fuel bowser based on a ZiS-150 lorry tows the '150' prototype ('150 V1') during ground tests. The '150' was a whale of an aeroplane, with a weighty yet sleek air about it. This view shows clearly the teardrop shape of the fuselage and the engine nacelles; from this angle the T-tail looks oddly like a whale's tail flukes.

able to resume work on the '150' on 20th October, while the others did not have a chance to do so until November. Since the State mock-up review commission had required numerous changes to be introduced into the design of the '140-B/R', the greater part of the design work on the '150' planned for November 1949 remained unfulfilled.

Scale model tests of the '150' in TsAGI's T-102 wind tunnel were completed in September-October 1949 with encouraging results. High-speed testing of the bomber's wings was conducted in TsAGI's T-106 wind tunnel. In October OKB-1 began a new redesign of the bomber because the powerplant was changed *again*: Aleksandr A. Mikulin's OKB-300 had sent in the specifications of its latest offering, the AMRD-03 axial-flow turbojet with a specified take-off thrust of 8,000 kgp (17,640 lbst). (This engine eventually reached production status as the AM-3.)

Meanwhile, the I-215D (*izdeliye* 155) was completed by factory No.21 and entered flight test in early November 1949 (the exact date is unknown). Like the future bomber, this testbed incorporated a main gear 'kneeling' feature to increase the angle of attack on take-off by 3°. This allowed the I-215D to become airborne without rotation, not requiring the pilot to haul back on the control stick. The aircraft displayed confident ground handling, showing no tendency to tip over on one wing even during sharp turns.

On 21st November Brunolf Baade chaired a meeting at which the specifications for the powered cannon barbettes (to be manufactured by plant No.25) were approved. On 30th November he held another meeting in order to finalise the engine type to power the '150' (TR-3A or AMRD-03) in accordance with a query sent in by MAP's 7th Main Directorate which had to make plans for 1950. This was a difficult issue, and to this day there are two theories as to how the engine type was ultimately chosen which are the opposite of each other. According to some sources, Baade advocated the use of AMRD-03 engines while Alekseyev proposed fitting TR-3As; while admittedly less powerful, the latter engine (later redesignated AL-5) was more compact and hence created less drag. Their opponents claim that it was Baade who supported the TR-3A and it took him a maximum of effort to persuade the bosses of OKB-1 that it was expedient to use the less powerful engines which were lighter, had a smaller frontal area and allowed engine nacelles with a more favourable fineness ratio to be used. Anyway, after a series of preliminary experiments the Lyul'ka engine won and was selected to power the bomber. Baade allegedly went to OKB-165 himself to secure TR-3A engines for the '150', and the result was felt immediately: calculations (later corroborated by the flight test results) showed that the choice had been a good one.

Another 250 blueprints for the '150' were issued in November 1949. On 6th (7th?) December Baade announced the task of modifying the bomber to take AMRD-03 engines in order to meet more stringent requirements concerning top speed and field performance posed by the customer. On 23rd December OKB-1 test pilots made the third and final preliminary test flight in the '145' control system testbed (the modified Ju 388L). In all three flights the elevators had been manually controlled; the hydraulic servo actuator was deactivated, pending permission to switch it on. All in all, by the end of the year OKB-1 had released 3,375 blueprints for the '150' (ie, for about 25% of the structure); yet, whereas the first metal had been cut, not a single airframe component had been assembled at the end of 1949.

On 2nd January 1950 the top executives and design team chiefs of OKB-1 had a meeting to discuss the revised blueprint issue schedules for the '150'. The deadline for the final completion of all drawings for the airframe structure was set at 30th March. On 4th February another meeting took place at the factory director's office; the prototype construction schedule was the subject this time and the completion date was slated for October 1950. Hydraulic tests of the Nos 1 and 2 fuel tanks began that same day.

The following dates from the prototype construction process are given to illustrate the breakneck pace at which the work proceeded.

On 14th February 1950 Baade came back from Moscow, bringing new specifications for the landing gear. Instead of the 1,170 x 435 mm 46.0 x 17.12 in) wheels for the nose/main units and the 750 x 200 mm (29.52 x 7.87 in) wheels for the outrigger struts that had been delivered to GOZ No.1 by then, the bomber was to feature 1,150 x 355 mm (45.27 x 13.97 in) nosewheels, 1,450 x 520 mm (57.0 x 20.47 in) mainwheels and 600 x 155 mm (23.62 x 6.10 in) outrigger wheels.

On 6th March a 1/16th scale model of the '150' was sent to TsAGI for testing in the T-106 wind tunnel. On 18th March the director of GOZ No.1 issued the first document dealing in earnest with the construction of the '150' prototype and preparations for series production (order No.81). On 4th April the plant received the first kilogram (2.2 lb) of the new Vi6-18 bonding/sealing agent to be used in the construction of the bomber's airframe and began experimenting with the stuff. Ten days later Arkhip M. Lyul'ka paid a visit to GOZ No.1 to help the engineers clarify certain questions concerning the bomber's powerplant. On 26th April the first forward fuselage (crew cabin) section was taken out of the assembly jig for further completion work. That month a major problem arose involving the manufacture of the wing spar caps, which were of welded construction.

On 5th May a sample fuel tank utilising the experimental honeycomb structure developed for the '150' was subjected to the first combat survivability test under a programme held by GK NII VVS – ie, fired upon for the first time. On 23rd May the plant completed the changes to the full-scale mock-up's forward crew compartment and tail gunner's station as required by the mock-up review commission. Meanwhile, assembly of the No.2 forward fuselage section began a week earlier, on 16th May; it was completed by 3rd June.

The problems with manufacturing the '150' bomber's airframe subassemblies grew increasingly acute in July 1950. The quality of the bonding/sealing agent became inconsistent, and the output of production sea-launched cruise missiles which were the plant's main products (GOZ No.1 had switched to production plant status in the meantime) enjoyed higher priority, causing ever more frequent delays in the prototype construction schedule. Also, the State mock-up review commission now turned its attention to the crew rescue system, examining, among other things, the ejection seat mock-ups; while these were generally approved, a number of design changes was deemed necessary, which meant further delays. In its protocol the commission demanded that separate State acceptance trials of the ejection seats be held ahead of the aircraft's State acceptance trials. Tests of a hydromechanical version of the flight control system on the 'iron bird' test rig began on 21st November 1950.

On 24th March 1951 the Council of Ministers issued directive No.949-469 ordering the development of the '150' bomber and specifying the date of its submission for State acceptance trials, followed shortly thereafter by an MAP order to the same effect. Thus the aircraft finally received official status.

On 1st April the State mock-up review commission received the bomber's provisional weight data based on the preliminary results of weighing the various airframe and systems components and adding up the figures. The data are detailed in the table at the foot of this page.

The State acceptance trials (ie, combat survivability tests) of the honeycomb construction fuel tank were completed on 18th April 1951; the tank proved capable of sustaining six hits without catastrophic damage. Ten days later the Air Force endorsed a revised SOR for the bomber and the factory took delivery of the first TR-3A engine. In June and July the plant manufactured the engine nacelles, the wingtip fairings, all four landing gear struts (less wheels) and the tail surfaces; the electric system installation was 70% complete and numerous hydraulic system components were installed by the end of July.

On 18th July the principal airframe components were moved to the assembly hangar where the fuselage was mated with the wings and tail unit by 1st August; test firing of all three ejection seats also took place in the same hangar. Shortly before that OKB-165 had taken the engines back for modifications in order to install new attachment trunnions and had not yet redelivered the engines by 1st August.

The second airframe (the static test article) was being manufactured concurrently; the German specialists at OKB-1 referred to it as the '150 V2' in keeping with the German tradition of designating prototypes. The wings and fuselage of the static test airframe had also been mated (though not yet finally joined together) by 1st August and some airframe components had already been tested. Twenty days later the tail unit was fitted and another two days later, on 23rd August, the static tests began in earnest.

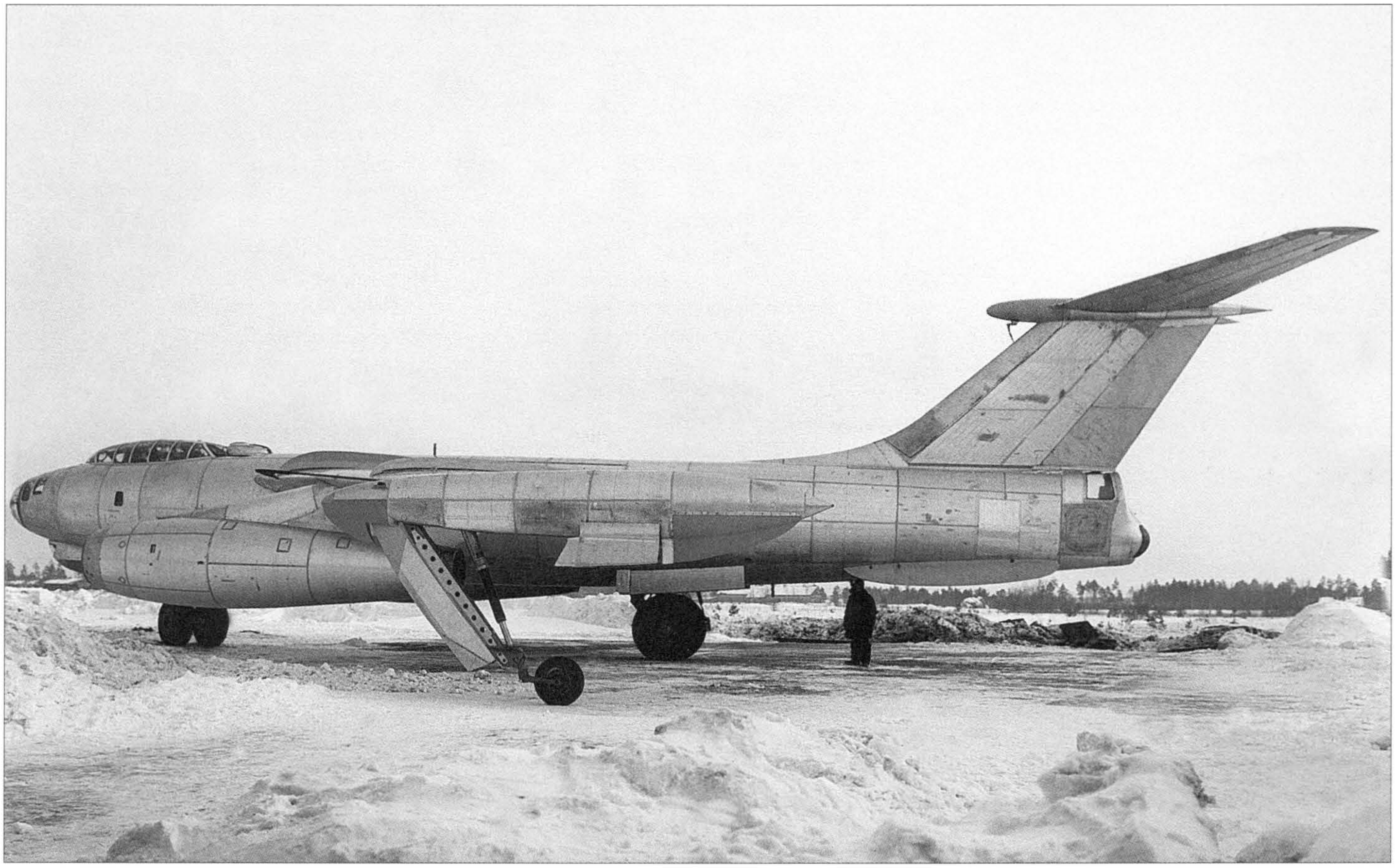
On 16th September 1951 the completed flying prototype was freed from all manufacturing fixtures and work platforms and photographed inside the hangar. Ground systems checks began immediately afterwards. These were not trouble-free: one of the integral fuel tanks, which were coated with special RA-6 varnish on the inside, developed a leak when filled with kerosene for the first time.

Approximately on 20th September a crew from LII was assigned to the '150' prototype for holding manufacturer's flight tests. By 8th October the ground test programme was about 30% complete; it turned out that the RA-6 varnish had been applied sloppily in more that one place, as new fuel leaks were discovered. On 15th October two of Arkhip M. Lyul'ka's aides were summoned to the plant to deal with the defects of the AL-5 engines. The following day, when the four drop tanks were fitted for the first time, the starboard

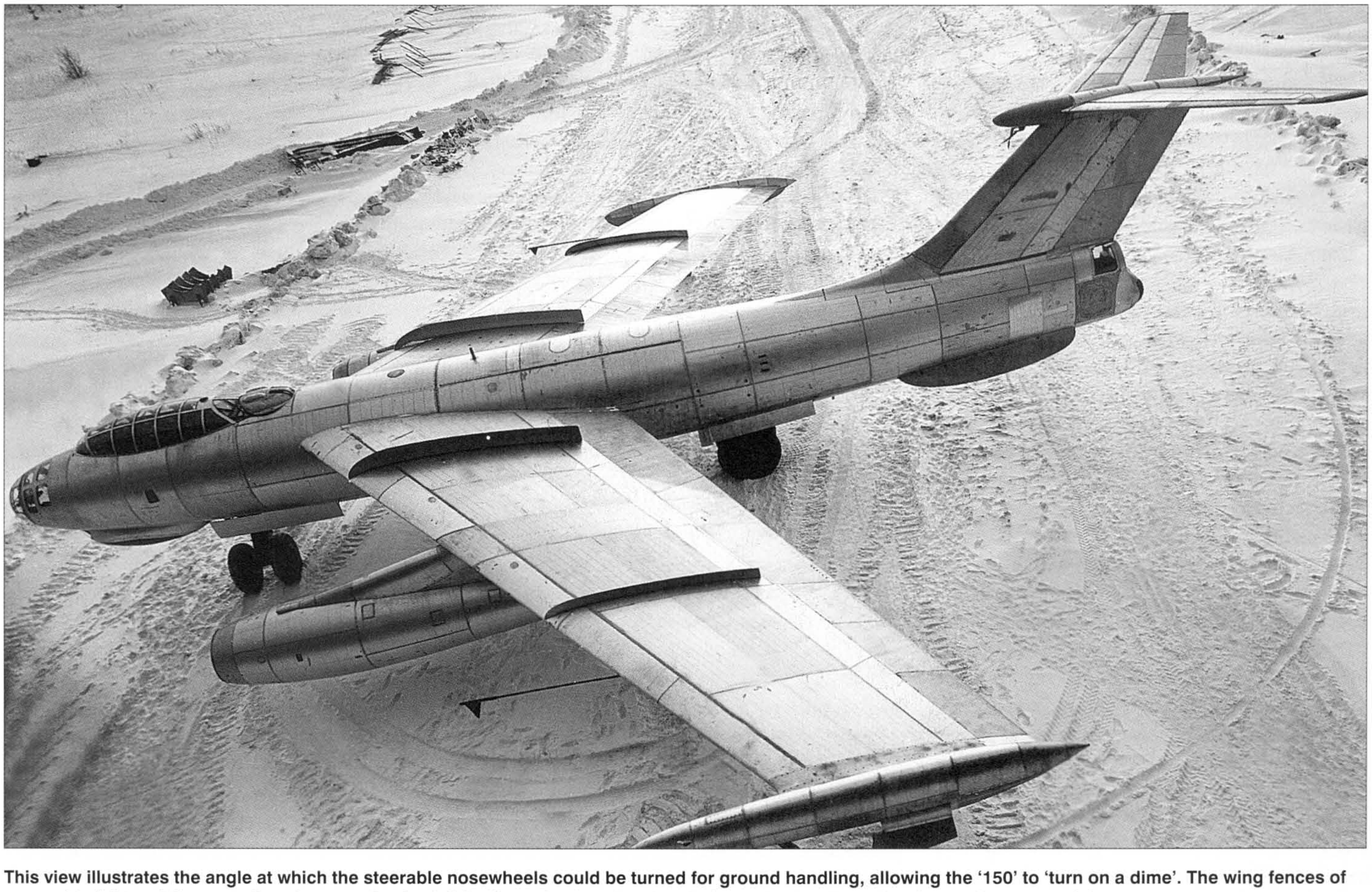
Weight data for the '150' bomber with TR-3A engines based on component weigh-in (prior to presentation to the State mock-up review commission)

Component	Weight as presented to the State commission 1-4-1951, kg (lb)	Actual weight, kg (lb)	Excess weight, kg (lb)
Fuselage	4,410 (9,722)	4,850 (10,692)	440 (970)
Wings	5,818 (12,826)	6,000 (13,227)	182 (401)
Tail unit	870 (1,918)	970 (2,138)	100 (220)
Landing gear	2,045 (4,508)	2,700 (5,952)	655 (1,444)
Outrigger gear fairings	n.a.	300 (661)	300 (661)
Engines	3,680 (8,112)	3,800 (8,377)	120 (265)
Engine jetpipes	n.a.	370 (815)	370 (815)
Fuel system	505 (1,113)	585 (1,289)	80 (176)
Armour plating	350 (771)	690 (1,521)	340 (750)
Electrics	642 (1,415)	850 (1,873)	208 (458)
Hydraulics	750 (1,653)	860 (1,895)	110 (242)
Avionics and equipment	n.a.	n.a.	126 (277)
Empty weight	22,680 (50,000)*	25,703 (56,664)*	3,013 (6,664)*
Normal all-up weight	32,000 (70,546)	36,613 (80,716)	4,613 (10,170)

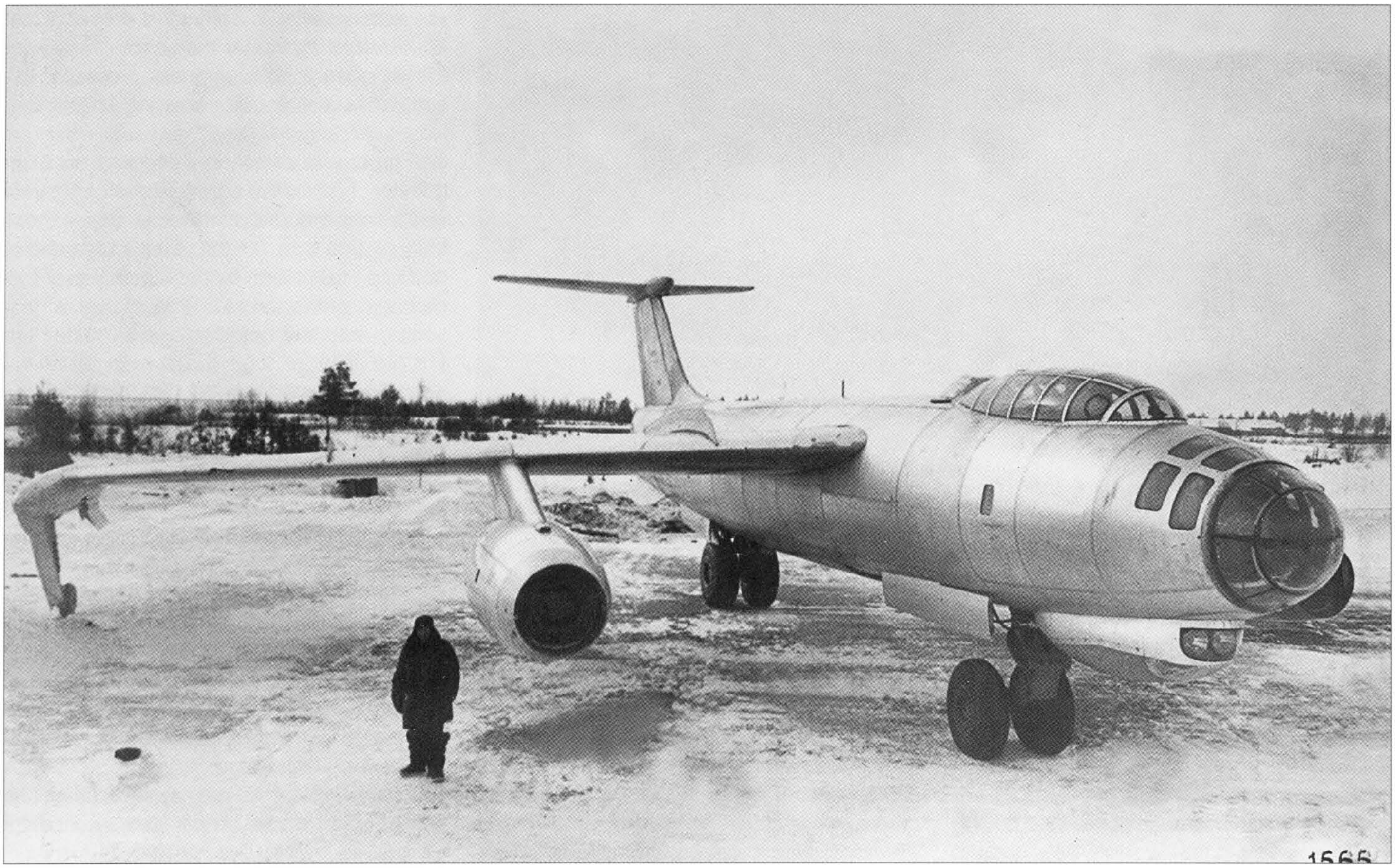
* Mechanically adding up the weights of the individual airframe components and systems gives a figure that does not tally with the advertised empty weight. This is due to, firstly, the impossibility to include certain equipment items which were not present on the mock-up and, secondly, the very provisional weight figures for individual components. The normal all-up weight of the '150' as per the prototype construction plan for 1951 was 36,000 kg (79,365 lb).



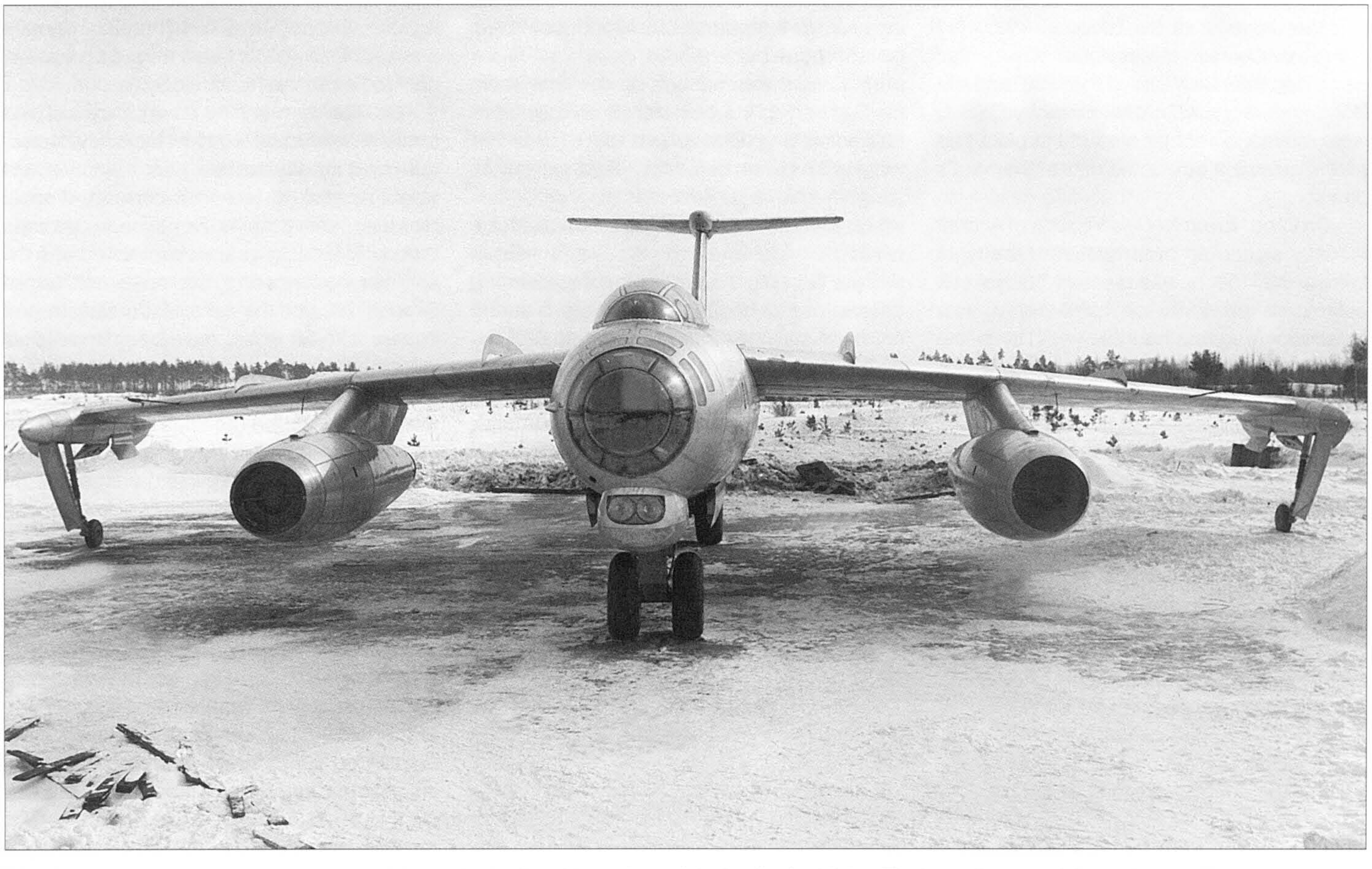
Above: The '150' at Borki airfield, the airfield of GOZ No.1, in December 1951 a few days after the rollout. The man standing under the tail graphically illustrates the bomber's large size.



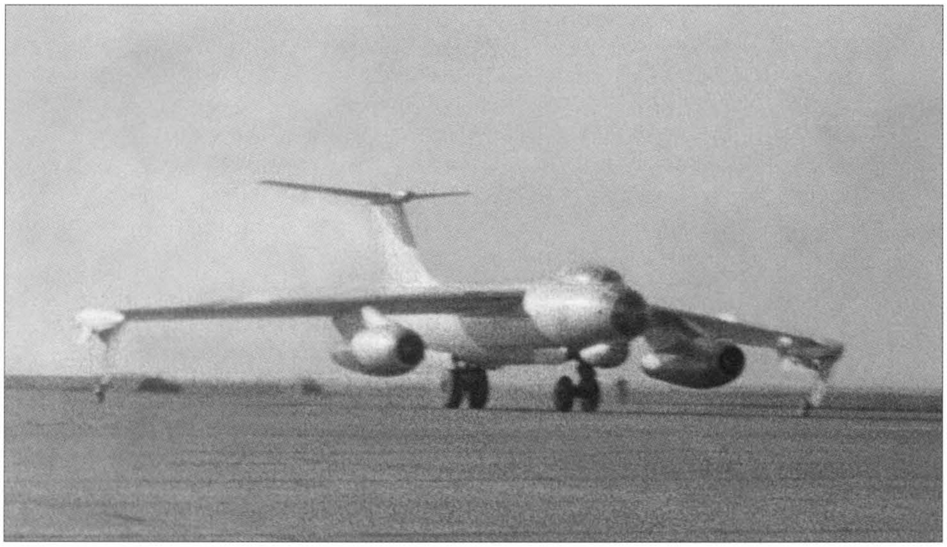
This view illustrates the angle at which the steerable nosewheels could be turned for ground handling, allowing the '150' to 'turn on a dime'. The wing fences of unequal height and the ventral strakes are clearly visible. Note also how far ahead of the wing leading edge the outrigger strut fulcrums are.



Above: Unlike many aircraft with a bicycle landing gear, the '150' sat fairly high above the ground. This view illustrates the large glazing area and the elaborate glazing framework which was uncharacteristic of Soviet aircraft. The stabiliser dihedral is clearly visible here.



The prominent chin fairing of the '150' housed the navigation/bombing radar and the landing/taxi lights. The large diameter of the engine nacelles is readily apparent.



This picture shows the '150' during a high-speed run at Lookhovitsy-Tret'yakovo where the flight testing took place.

inboard tank suddenly dropped spontaneously because the lock had not engaged properly.

Vibration tests were performed on 25th-28th October. The first weigh-in of the complete aircraft took place on 31st October, followed by the second one on 31st October/2nd November. The result was disheartening: the machine turned out to be 2,000 kg (4,410 lb) overweight.

On 10th November the main landing gear unit's mounting truss failed at 100% of the design load during static tests. It turned out that the diameter of the tubes of which the truss had been made was too small. That same day the mock-ups of the '150' and the '151', another bomber developed by OKB-1, were moved to another area of the plant and partially dismantled at the orders of the plant's director.

On 22nd November the Minister of Aircraft Industry signed an order requiring the flight tests of the '150' to take place at Tret'yakovo airfield in the town of Lookhovitsy near Moscow – ie, more than 200 km (124 miles) from Plant No.1. The reason for this was that Tret'yakovo had an adequately long runway, whereas the runway at Borki (the factory airfield of Plant No.1) was too short for testing heavy aircraft. (It should be borne in mind that, with an all-up weight of around 38 tons (83,770 lb), the '150' was 50% heavier than the '140'.) The aircraft was to be formally delivered to the plant's flight test facility on 31st December; however, the plant obstinately refused to include some crucial test and development programmes (the tests of the 'iron bird', the twin-chamber landing gear shock absorbers, certain hydraulic actuators etc.) into the bomber's completion work plan; as a result, the completed aircraft could not be accepted because the delay with these programmes was holding up the works. On 8th December Brunolf Baade issued an order forbidding any modifications to the prototype without his personal authorisation.

The following illustrates the difficulties which the engineers of OKB-1 had to tackle when defining and refining the bomber's design. On 11th December the main landing gear unit's mounting truss failed again during renewed static tests, cracking at 95% of the design load. On 26th December the prototype was finally rolled out, the first engine run taking place the following day; the start-up was not accompanied by anything untoward but the throttles (or rather the control runs from the throttles to the engines) proved to be somewhat resilient, not allowing engine rpm to be adjusted precisely. Fuel usage from several groups of tanks was checked on 26th-30th December; the aggregate engine thrust was also measured on the latter date, constituting 7,500 kgp (16,530 lbst) plus another 750 kgp (1,653 lbst) lost to landing gear friction against the tarmac. With all due corrections made the engines gave 8,500 kgp (18,740 lbst) of total thrust instead of the advertised 10,000 kgp (22,040 lbst). On 30th December the aircraft was hangared again for modifications and additional ground tests. Static tests of the nose gear unit were held on 2nd January 1952; this time there were no surprises, but on 6th January there was trouble with the main gear unit again – the hydraulic downlock failed when the 'kneeling' feature was being checked.

On 8th January the extended flaps refused to retract; it took several tries to get them up. On 12th January vibration of several actuator screws located in the fin leading edge was detected during checks of the hydromechanical control system; also, the anti-vibration brake of the starboard centre elevator segment failed. On 28th January fuel was somehow forced into the hydraulic system under pressure during a routine engine run; as a result, hydraulic pressure rose by 2.5 kg/cm^2 (35 psi) and a hydraulic reservoir cracked. This incident also turned up another design flaw in the hydraulic system.

On 30th January the emergency fuel jettison valve of the fuselage fuel tanks was tested; the following day the navigator's ejection seat was successfully test-fired from the aircraft. However, more spills came soon enough. When the landing gear was retracted with the engines running and the nose unit turned through 20° (for the sake of experiment – of course take-off would have been impossible with the nosewheels at such an angle!), it transpired that the nosewheels could not assume the neutral position quickly enough as the gear retracted. As a result, one of the nose gear components was damaged.

On 4th February Brunolf Baade chaired a meeting, stating that he had been ordered by the director of Plant No.1 to start dismantling the aircraft for transportation to Lookhovitsy by rail. Before the trip could be made, however, more than 50 defects had to be eliminated. The ground test programme, including engine runs, was completed on 19th March. Baade stated that errors had been made in calculating the parameters of the cabin pressurisation system and ordered new calculations to be made.

Disassembly of the '150' prototype began on 29th March. The following day Vice-Minis-

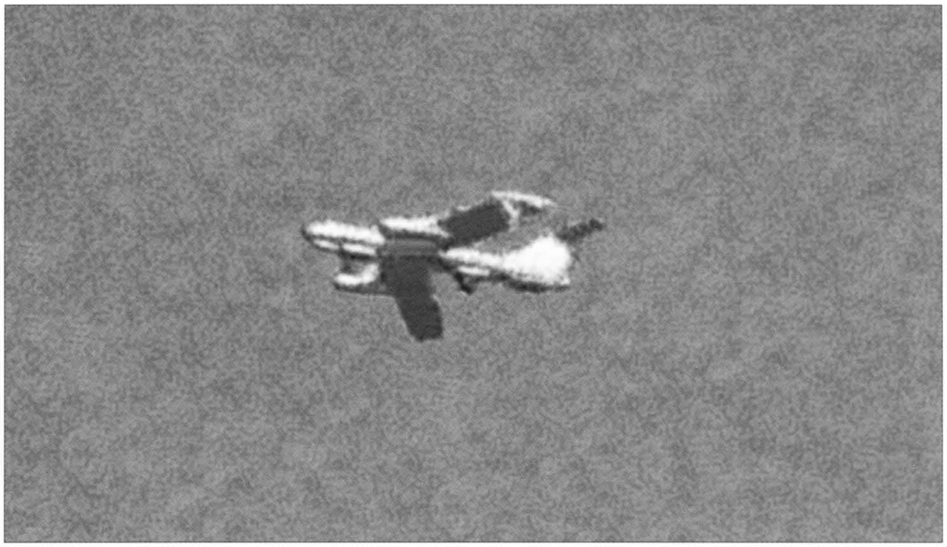
The '150' a few seconds after taking off on its maiden flight on 5th September 1952. Note the partially retracted main gear strut to increase the angle of attack for lift-off.

ter of Aircraft Industry S. N. Zhitkin came to the plant to examine the aircraft. By 2nd April the technical documentation for the aircraft was still incomplete; therefore Baade held another meeting, ordering that a complete set of documents be prepared not later than mid-May. The following day a working meeting fixed the relocation schedule: the aircraft was to be transported to Lookhovitsy on 15th-20th April and reassembled there on 10th-15th May in order to commence taxying tests before 1st June, which was tentatively set as the first flight date.

On 17th April 1952 the railway train carrying the crated aircraft and the supporting personnel finally left Bol'shaya Volga station, arriving in Lookhovitsy three days later; the flight test facility of OKB-1 also moved to the new location. On 5th May the plant sent a modified vertical tail for the bomber to Lookhovitsy; manufacturer's tests of the hydromechanical flight control system on the 'iron bird' began two weeks later, on 19th May. On 30th May the pilot's and gunner/radio operator's ejection seats were sent to LII for manufacturer's tests; the seats were equipped with suitably adapted ejection guns originally developed by the Ilyushin OKB for a different aircraft.

On 16th June Baade came back from Lookhovitsy and observed that the ground next to the runway was a grass field with a low bearing strength; a shower of rain was enough to turn it into a bog that was completely unsuitable for landing. On 24th June TsAGI submitted their report on the '150' bomber's structural strength, whereupon it was decided to complete the ground systems checks by 12th July and hand the aircraft over to the flight test facility on 18th July; taxi tests were scheduled for 22nd-25th July.

Thus the relocation to Lookhovitsy caused the flight tests to be postponed until August 1952. Yakov I. Vernikov, a holder of the Hero of the Soviet Union title and a one-time combat pilot who became a Test Pilot 1st Class at LII after the war, was appointed project test pilot. On 8th-11th August he made 19 taxi runs at speeds up to 180 km/h (111 mph) on the paved main runway and up to 120 km/h (75 mph) on the auxiliary grass runway. In the latter case the aircraft was seen to rock dangerously because of the uneven runway surface and the insufficient energy absorption of the landing gear oleos. Hence the oleo struts were removed and reinstalled after modifications had been made. The aircraft was declared ready for flight testing after a few defects had been rectified and a further high-speed run had been made. This taxi run was performed on 2nd September, the aircraft attaining a speed on 200-220 km/h (124-136 mph) on the concrete runway. The test was marred by failures in the nose gear unit's steering system.



Though of poor quality, this still from a ciné film is interesting, as it is one of very few shots of the '150' in flight.

On 3rd September 1952 the '150' was finally ready to fly, but the flight had to be delayed because the airfield had become soggy after a rainfall. Finally, at 13:00 Moscow time on 5th September the bomber became airborne for the first time with Vernikov at the controls and flight engineer Ye. N. Zharkov in the co-pilot/radar operator's seat; the crew also included a navigator and a radio operator.

The defensive armament was not yet installed for the initial flight tests. After the cannons had been installed, GK NII VVS test pilots took over. S. N. Rybakov was OKB-1's engineer in charge of the flight tests, with I. N. Kvitko being assigned the same responsibilities at LII. OKB-1's Deputy Chief Designer P. N. Obroobov often attended the test flights. The second test flight took place on 9th September, the third flight following on 11th September, the fourth on 24th September and the fifth on 27th September. The flight scheduled for 29th September was cancelled when the communications radio failed.

After the first five flights the following report on the initial flight tests was drawn up. Curiously, it was not endorsed until 1953 (it was fairly common practice in the Soviet Union to sign such paperwork with a considerable delay: procrastination on the part of bosses at various levels was the order of the day). The report is quoted in full, as the fact in itself that a heavy jet bomber for the Soviet Air Force was developed from scratch by German engineers is of considerable interest.

'1. Introduction

*The '150' aircraft – the prototype of a jet bomber designed by Baade and powered by two AL-5 engines designed by Lyulka has been built by the Experimental Plant No.1 of the Ministry of Aircraft Industry pursuant to the Council of Ministers' directive No. ****** dated *****.*

Manufacturer's tests of the '150' aircraft were conducted at Tretyakovo airfield belonging to facility No.3 of the Ministry of Aircraft Industry.

Five flights were performed on the '150' aircraft between 5th September and 27th September 1952. Already in the course of these five flights it proved possible to obtain data which characterise the aircraft's aerodynamic properties, controllability and handling at high Mach numbers, as well as data on the functioning of its mechanisms, the most important of which are the bicycle-type steerable undercarriage and the aircraft's hydromechanical control system.

Among other things, the following results have been obtained:

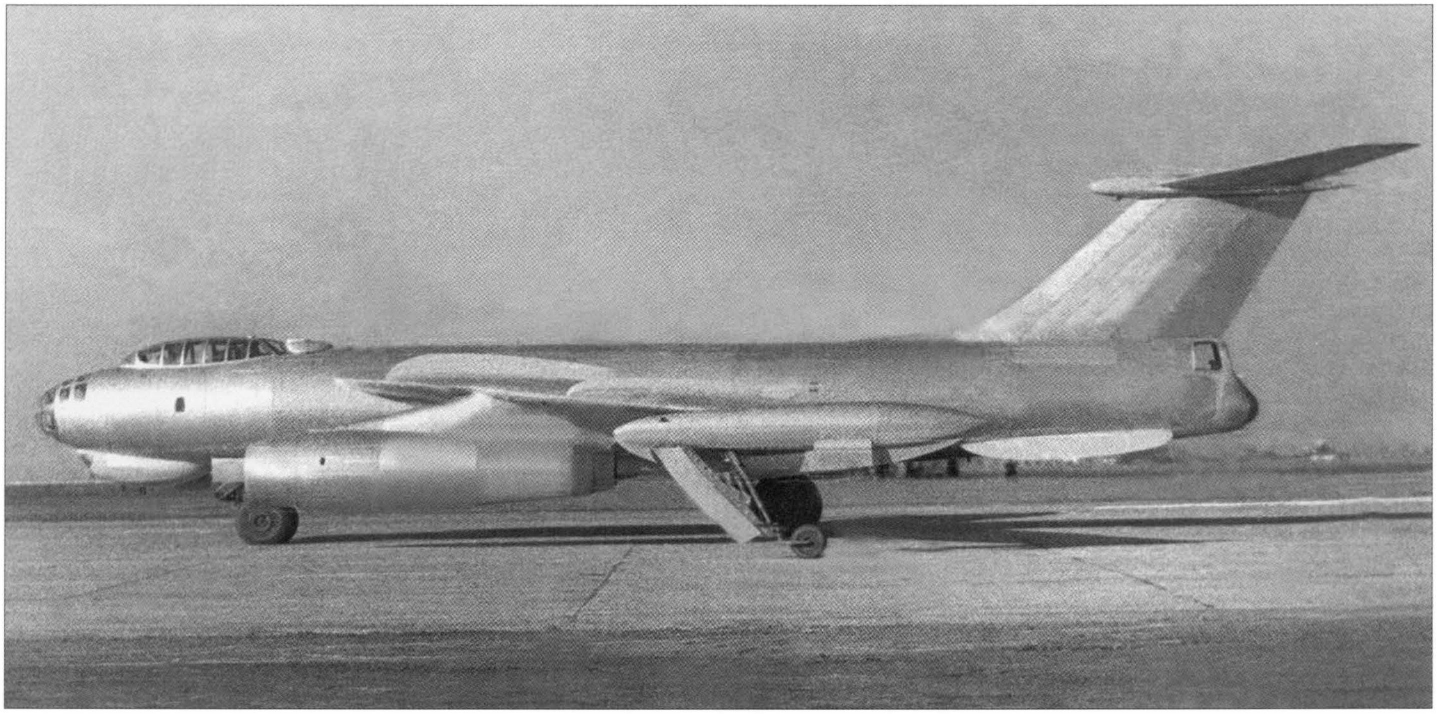
I. Field performance

The aircraft possesses normal controllability during taxying, the take-off run and the landing run. The bicycle undercarriage enables the aircraft to move steadily on a straight-line course, and the system of new high-pressure pneumatic shock absorbers has demonstrated good shock-absorbing qualities.

The steerable nose gear unit makes it possible to perform precise control of the aircraft up to the unstick speed without making use of brakes or differential engine thrust; at slow speeds (during taxying) it makes it possible to make a turn with a radius virtually equal to the aircraft's wing span.

While performing a take-off run with a normal take-off weight, the aircraft 'kneels' gradually; at the end of this process the take-off angle of attack is reached, followed by a normal lift-off. The obtained take-off run lengths corroborate the estimated characteristics.

All flights were performed with a cross-wind speed of 6-12 m/sec [12-24 kts].



The '150' taxies on the concrete strip at Lookhovitsy-Tret'yakovo. The aircraft was devoid of markings throughout its flying career.

The landings were performed at the maximum landing weight, the gliding approach speed was 280 km/h [174 mph].

The braking system designed by Plant No.279 functioned poorly (the wheels locked); on two occasions this caused the tyres of the nose and rear struts to separate from the wheel rims.

II. Speed

The following figures have been obtained in these flights:

maximum Mach number 0.9;

maximum dynamic pressure 3,000 kg/m^2 [614 lb/sq ft];

maximum speed in level flight at 4,600 m [15,090 ft] – *965 km/h* [599 mph];

(more exact figures will be given after a calibration flight).

III. Controllability

The aircraft's controllability and handling at speeds from the take-off speed to those quoted above were normal: no reverse roll reaction to rudder inputs was noted, nor was there any aileron reversal. At maximum speeds the aircraft has a positive pitching moment of a value which coincides with the calculated value.

In the pilot's opinion, the functioning of the hydromechanical controls of the '150' aircraft in flight does not differ in any way from that of the usual controls.

IV. Stability

Longitudinal stability with regard to control forces, with the CG at 24-27% MAC, is normal.

V. Functioning of the aircraft's airframe, units and systems

a) No structural defects worthy of note were discovered.

b) The aircraft's hydromechanical controls functioned normally in all flight modes. No defects were discovered.

c) Despite landings with crosswind and high-speed taxying on an uneven surface, the steerable bicycle undercarriage, proved to be reliable and demonstrated normal shock-absorbing qualities.

d) The pressurised cabin and the high-altitude equipment, when tested at altitudes up to 8,700 m [28,540 ft], *demonstrated characteristics tying in well with the design characteristics; the temperature in the cabin was normal (between +16°C and +23°C) at an ambient temperature of –43°C.*

e) The Lyulka-designed AL-5 turbojet engines fitted with Tarasov-designed Model 417 hydraulic pumps ran faultlessly in all flight modes.

f) The aircraft's fuel system making use of integral tanks in the hermetically sealed sections of the fuselage and fitted with a new (honeycomb) protection system functions faultlessly.

VI. Defects

1. As a result of imperfect functioning of the braking system, the tyres had to be changed twice on the rear wheels and once on the nosewheels. The defect has been eliminated temporarily. It will be finally cured by Chief Designer Bashta.

2. There are faults in the functioning of the extension mechanism of the tactical air brakes. The faults will be eliminated by removing the hydraulic locks.

3. The captured German fuel quantity indicators are imprecise. They will be replaced by indicators of Soviet manufacture as soon as these are available.

4. Several units of the fuel system and hydraulic system were replaced due to poor-quality rubber parts.

5. The artificial horizon and the mast of the flux-gate compass failed to function and had to be replaced twice; the RV-2 radio altimeter is imprecise.

6. Changes and improvements were introduced into the recorder equipment.

VII. Particularly notable difficulties encountered during the flight tests

Construction work is still in progress at Lookhovitsy airfield; it comprises not only the work on the completion of the construction of the hangar and its amenities and heating, but the work on the runway and taxiways as well, which seriously impedes the fulfilment of the flight test programme, because the work on the runway does not stop even during the flights.

The most essential catering for the needs of the flight test preparations is non-existent: there is no weather service, telephone and radio communication, no marker radio beacon, no kerosene refueler, no running water, no sewage, no heating, no workshops, no measurement and instrument laboratories, no canteen etc.

All these deficiencies affect very much the tempo of work on the flight-testing of the aircraft.

Conclusions

1. The maximum speed of 987 km/h [613 mph] *attained by the '150' aircraft at an altitude of 4,500 m* [14,760 ft] *considerably exceeds the maximum speed of 970 km/h* [603 mph] *stipulated by the specific operational requirement.*

2. The maximum Mach number attained by the '150' aircraft during a shallow descent at an altitude of 7,400 m [24,270 ft] *is 0.89. The aircraft's behaviour, as well as its stability and controllability, were normal on this occasion.*

3. The aircraft's minimum static stability margin is equal to 6% MAC, which meets the general technical requirements.

4. Efficiency of control surfaces, including the ailerons, of the '150' aircraft is quite sufficient in all flight modes, including a sudden failure of one engine.

5. The '150' aircraft is dynamically stable. The degree of oscillation damping which was determined in flight exceeds the calculated value.

6. The values of fuel burn per hour measured on the '150' aircraft's port engine are somewhat lower than the fuel burn values specified by the engine manufacturer and used for calculating the range. Since the speeds attained at these stages match the design speeds, there is good reason to surmise that the calculated range will be attained.

7. The climb rates attained by the '150' aircraft at the engines' nominal thrust rating are lower than the design value by 1-2 m/sec [197-394 ft/min]. *However, these characteristics are not precise enough because the data required for determining the climb rate were obtained in only two flights; besides, the temperature of the engines' exhaust gases in these flights at nominal rpm was lower than the normal value. Increasing the turbine temperature to the normal value will, naturally, be accompanied by an increased rate of climb. Further flights within this programme are necessary to obtain more precise results.*

8. Field performance: during the take-off run, take-off, landing and landing run the '150' aircraft demonstrates stable and normal behaviour. The take-off run proved to be marginally longer than anticipated because the fuselage's angle of attack after the 'kneeling' of the undercarriage was reduced from the 6° envisaged in calculations to 5°. It is possible to reduce the length of the take-off run obtained so far by some 150 m [490 ft] *by deflecting the flaps simultaneously with the 'kneeling' of the undercarriage.*

9. The hydromechanical controls of the '150' aircraft functioned faultlessly and in full accordance with technical requirements. Functioning of the load feel unit must be studied further.

10. The elevator control column travel should preferably be increased in all flight modes except take-off and landing; this can be done by switching off one of the lines of control shafts in flight.

11. The bicycle undercarriage of the '150' aircraft, the nose gear steering mechanism, the main unit 'kneeling' mechanisms and the auxiliary underwing struts' retraction mechanisms functioned faultlessly and in full accordance with the technical requirements during the flight tests; they fully ensured normal execution of take-offs and landings with a crosswind of up to 10-12 m/sec [20-24 kts].

The undercarriage ensured the aircraft's movement in a straight line during the landing run even after the tyres of all four mainwheels were 'shorn off' as a result of the landing with the wheels locked.

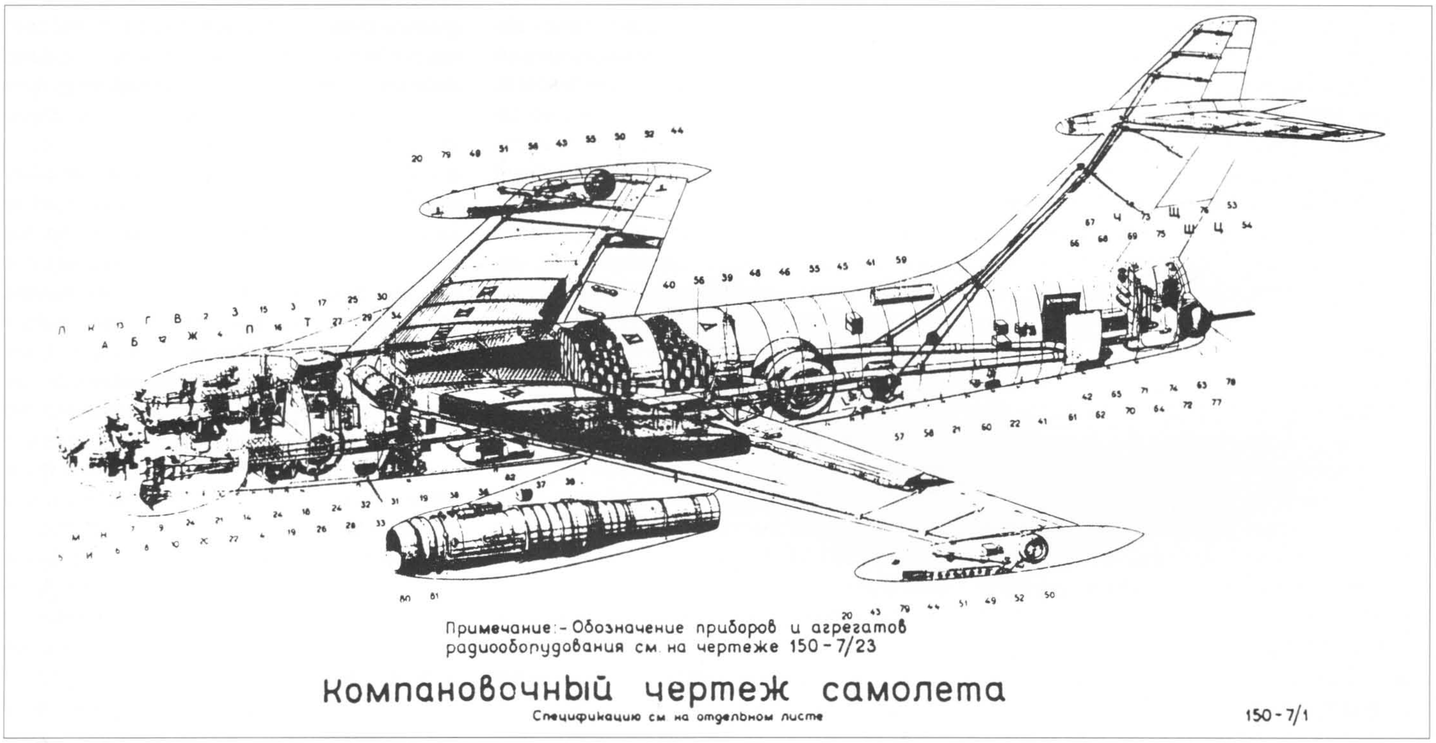
12. The wheel braking system incorporating an anti-skid unit was repeatedly modified in the course of the tests in accordance with instructions from Comrade Bashta, Chief Designer of this system. After modification the system basically met the specifications. However, the tests revealed that performing the braking of an aircraft fitted with this braking system requires the pilot to be very attentive and have some experience, and does not ensure in practice the shortest possible landing run; in some landing situations (such as braking after a touch-down and subsequent ballooning which passes unnoticed by the pilot) one cannot rule out serious damage.

To make this system more reliable and efficient, its design should be supplemented by the following main features:

a) to rule out feeding full pressure to the brakes before the wheels have accelerated to full rpm during the landing run;

b) to immediately cancel the pressure in the wheel brakes, should the wheels stop rotating;

c) to incorporate into the braking system a pressure modulator which will minimise the number of pressure fluctuations during the operation of the anti-skid device.


Примечание:- Обозначение приборов и агрегатов
радиооборудования см. на чертеже 150 - 7/23
Компановочный чертеж самолета
Спецификацию см на отдельном листе
150 - 7/1

A cutaway drawing of the '15C' Note that the engines are fitted with extension jetpipes for integration with the optimum nacelle shape and fineness ratio.

The above-mentioned additions will rule out the locking of the wheels during braking; they will reduce the fatigue stresses on the structural elements of the undercarriage and will ensure the minimum length of the landing run after the touch-down.

13. The air brake, when opened fully at indicated airspeeds of 400-500 km/h [250-310 mph], *causes undamped oscillations of the aircraft around the vertical axis. To eliminate this deficiency, it is necessary to change the design of the panels of the air brake by replacing the solid inner panel with a perforated one. Such changes have been developed by now in the OKB-1.*

In the course of flight testing the aircraft systems, namely:

- the hydraulic system for general controls,

-the hydraulic system for hydro-mechanical controls,

- the fuel system,

- the navigation system,

- the cabin pressurisation system,

- the powerplant,

functioned faultlessly and fully met the technical requirements.

15. The electric system, after some defects in the warning devices (revealed at the beginning of the tests) had been cured, functioned faultlessly and fully met the specifications.

Compiled by:

(signed) Chief of the flight mechanics team Schumann;

(signed) Deputy chief of the team Potashnikov;

(signed) Test engineer Lehmann.'

On 2nd October Chief Designer Baade reported the state of affairs concerning the '150' aircraft to the Minister of Aircraft Industry. The Minister gave orders stipulating the completion of manufacturer's tests and of all the work on the machine by 15th December 1952. On 20th October Deputy Chief Designer P. N. Obroobov issued instructions to start preparing the documentation on the aircraft with a view to submitting it for State acceptance trials and (!) *putting it into series production*.

In the process of manufacturer's flight tests the wing-tip fairings for the outrigger wheel struts were modified and turned into wingtip endplates. This was suggested by aerodynamicist L. V. Balkind as a measure intended to reduce the spillover of the airflow around the wingtip, when the need arose to eliminate the self-induced lateral swinging which developed into swinging around all three axes. During a landing approach at altitudes ranging from 300 m to 150 m (980 to 490 ft) the machine started swinging around its CG like a spinning top. When the height of the wingtip fairings was increased and their lower edges were made wedge-shaped, the swinging disappeared. At the same time the wings' induced drag diminished and the ailerons became more efficient.

On 23rd October the state of affairs concerning technical drawings was summed up. As it turned out, a total of 18,023 drawings and 5,943 parts lists for the aircraft had been issued. A schedule providing for the completion of factory tests by 15th December 1952 was not endorsed in the Ministry of Aircraft Industry as obviously unrealistic.

No flights were made until 14th November because of bad weather, but on that day the sixth flight took place, followed by the seventh flight on the following day; after that a leak was discovered in the No.3 fuel tank in the central integral section. On 19th November the '150' performed its eighth flight.

On 1st December specialists who came to Plant No.1 from Lookhovitsy said that the aircraft's being short on speed was due to incorrect calculations when interpreting the flight recorder data. The static pressure had been measured from the bomb bay. Concurrently it came to light that the performance of the AL-5 engines stated by OKB-165 (and purporting to be actual) differed from the real characteristics. Therefore the speeds attained by the '150' aircraft at different altitudes were somewhat redistributed.

On 22nd December during a conference held by Baade a decision was taken to install spring-loaded rods in the elevator and rudder control linkage; this took some time in connection with minor alterations that had to be made in the cabin. A month later, on 21st January 1953, when the aircraft was performing one of its regular high-speed runs, the machine went into an uncontrollable turn on the icy runway. The aircraft brushed one of the fir trees which were lining the runway; as a result, branches were ingested by one of the engines. Following instructions from Plant No.165, the engine was removed from the aircraft. On 30th January the factory tests of a photo reconnaissance package with an AFA-33/75 camera (designed for installation in the bomb bay) were completed and the replacement engine was test-run on the aircraft. On 4th February a taxying run was made on the runway covered with hard-packed snow. The next flight was scheduled for the following day, but was cancelled because the pilot did not turn up. On the same day the factory personnel discovered a defect in the nose gear unit's retraction mechanism, whereupon a telegram was sent from the factory to Lookhovitsy calling a temporary suspension of the flights.

On 16th February 1953 MAP issued order No.216 appointing co-pilot D. V. Zyuzin as back-up project test pilot due to the departure of test pilot Yakov I. Vernikov on a prolonged mission elsewhere. Until 20th February Zyuzin made several taxi runs; on 23rd February he studied the aircraft's controls on a simulator. On 20th February the Minister of Aircraft Industry signed Order No.220 on measures intended to speed up the factory tests of the '150' aircraft.

On 13th March Vernikov performed a check-up flight, the ninth in the series, and on the following day he made one more flight as a test sortie. Again an insignificant leak was discovered in the No.4 fuselage fuel tank. The first members of the State commission for the testing of the hydromechanical controls arrived at the Plant; they acknowledged that everything was ready for the tests. On 16th March Vernikov performed the 11th flight (in official documents it is listed as the tenth flight, because there are discrepancies in some documents as to the total number of flights performed, the figures differing by just one flight). On the following day the machine made the 12th (11th) flight, again with Vernikov at the controls.

On 19th March 1953 information on the progress of the tests was sent to the Ministry of Aircraft Industry; subsequently it was formalised into a special report. All the basic novel design features, the result of arduous work performed by the creators of the aircraft, functioned without any serious faults. However, certain deficiencies and even peculiarities in the machine's behaviour came to light. For example, longitudinal instability associated with speed and CG changes was revealed; at altitudes between 9,000 and 10,000 m (29,520-32,810 ft) during flights at maximum speed the aircraft had a propensity for small gradual longitudinal oscillations with the control column in the fixed position. Lateral swinging during descent, developing into oscillations around all axes, was eliminated by modifications to the airframe.

The design performance was generally attained and in some cases even exceeded. At an empty weight of 26,860 kg (59,230 lb), the normal take-off weight was 38 tonnes (83,790 lb), the maximum TOW being 47 tonnes (103,635 lb); the maximum landing weight was 32 tonnes (70,560 lb). The normal fuel load was 9,000 kg (19,845 lb), maximum fuel load with three auxiliary fuel tanks in the bomb bay was 18,800 kg (41,454 lb). Maximum speed was 790 km/h (491 mph) at sea level, 970 km/h (603 mph) at 5,000 m (16,400 ft) and 930 km/h (578 mph) at 10,000 m (32,810 ft); the landing speed was 210-215 km/h (130-134 mph). The bomber climbed to 5,000 m (16,400 ft) in 5 minutes and to 10,000 m (32,000 ft) in 18 minutes. The take-off run on turbojet power alone was 1,200 m (3,936 ft); with the use of four Type 129-1 solid-fuel JATO boosters designed by I. I. Kartukov (each delivering a thrust of 2,000 kgp/4,410 lbst for

17 seconds) the take-off run was reduced to 700 m (2,970 ft). The landing run was 700 m. The range, depending on the combination of fuel and bomb loads, could be anywhere between 1,500 to 4,500 km (930-2,800 miles), and the maximum endurance was 5.6 hours.

On 21st March test pilot D. V. Zyuzin lifted the machine into the air for yet another flight. The 13th flight took place a week later. Vernikov was unable to fulfil the flight mission because during climb a window panel of the cockpit canopy incorporating a clear-vision window cracked at an altitude of 9,500 m (31,160 ft). A new window panel was sent to Lookhovitsy on 4th April.

On 31st March a State commission arrived at the factory for the testing of the control system. This time the test rig was deemed not ready, and the commission did not commence work until 16th April. The following day Vernikov performed the 16th flight under the programme (listed as the 14th in official documents). The mission again remained unfulfilled because of the failure of the automatic artificial-feel unit in the control system (at high altitudes the control forces on all controls 'disappeared'). During a landing with the wheels braked the tyres of the nosewheels and mainwheels were ripped off and the nosewheel discs were deformed. At a conference Baade made a point of the fact that a few days earlier a similar incident had happened with an aircraft designed by Chief Designer Vladimir M. Myasishchev (the aircraft in question was the first prototype of the M-4 – *Auth.*).

On 9th May 1953, the Victory Day in the USSR, Yakov I. Vernikov finally succeeded in fulfilling the flight mission while performing the 17th (officially the 15th) flight. However, on that day he made one more flight – which proved to be the aircraft's last. When making a landing approach straight into the sun, Vernikov made a mistake in calculating the glide slope and pulled the stick when it was still too early to do that. The aircraft ballooned upwards, lost speed and fell on the runway from a height of 5-10 m (16-33 ft), the aircraft bouncing violently. The nose gear unit was ripped off, the upper attachment point of the main gear unit was severely damaged, and the machine continued slithering along the runway, resting on the engine nacelles and the outrigger wheels; fortuitously, none of the crew were hurt.

A damage assessment was made, according to which the aircraft would be repairable but the repairs would cost something between 100,000 and 300,000 roubles (within 8% of the aircraft's price). On 18th May Baade declared that the repairs could be effected only at the facilities of Plant No.1. However, this plant was so overburdened with producing missiles that this appeared unrealistic.

Baade quoted the following figures:

- The cost of the flying prototype of the '150' aircraft was 1.9 million roubles;
- The cost of the static test airframe was 1.1 million roubles;
- The cost of the manufacturing jigs and tooling was 800,000 roubles;
- The cost of the test facilities was 500,000 roubles.

All this added up to 4.3 million roubles. Nevertheless, a decision was taken at the conference to start repairing the aircraft immediately.

Although the flight testing had an unhappy end, the flights performed by test pilots had demonstrated that on the whole the '150' bomber met the requirements of the official specification and even exceeded some of them. For example, the maximum speed at sea level was 60 km/h (37 mph) higher than stipulated.

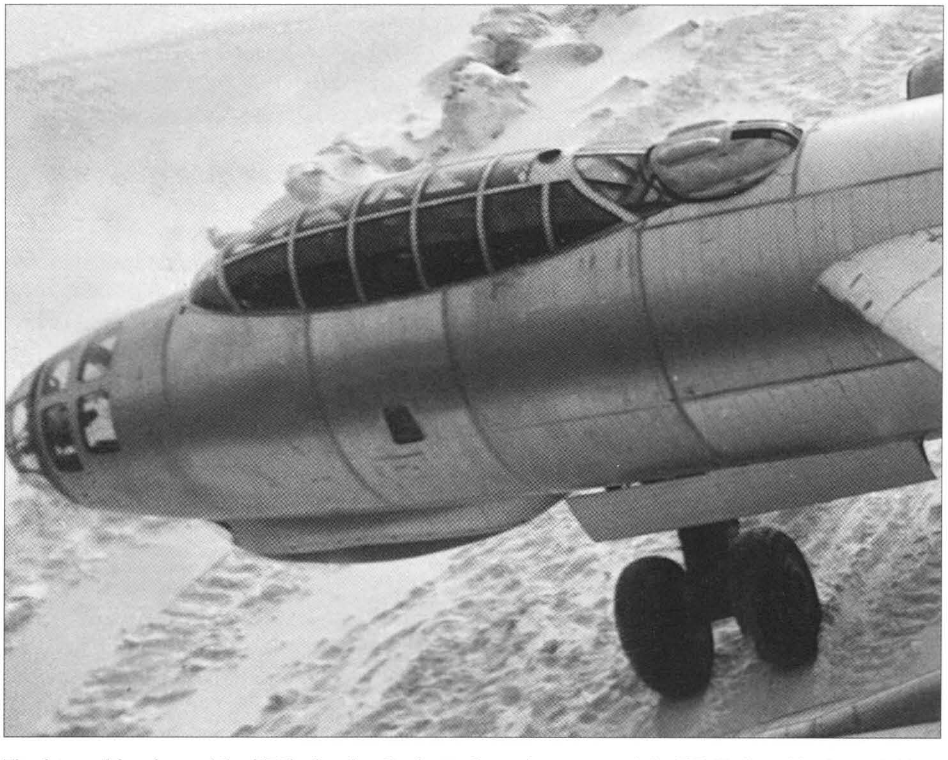
On 2nd June 1953 State trials of the cannon installations were completed at the factory, and 10th June saw the completion of testing of the hydro-mechanical control system. The preliminary appraisal was positive.

On 3rd June Minister of Defence Dmitriy F. Ustinov signed Order No.136 demoting LII test pilot Yakov I. Vernikov to Test Pilot 2nd Class. The order also contained a phrase about 'deficiencies' of the '150' aircraft and called for curing them.

In May-June the production Plant No.1 accomplished no work on the systems of the bomber, except for the testing of the photo reconnaissance pack with the AFA-33/100 aerial camera which was conducted between 23rd and 26th June. On 24th June a Government commission arrived at Lookhovitsy to assess the progress of preparations for the repairs of the aircraft; however, on 2nd July the German specialists resigned in connection with their departure. The results of the work of every design team were summed up in official documents.

On 29th August Baade sent a letter to Pyotr V. Dement'yev, the then first deputy Minister of Aircraft Industry, in which he contested the contents of the previously issued MAP order No.136 dealing with the incident with the '150' aircraft. On 14th September Plant No.1 received instructions from MAP's 7th Chief Directorate requiring the Plant to disassemble the '150' bomber and stow it away 'until further notice'; from then on, it was a downhill road for the '150'. On 6th October the mock-up of the aircraft was broken down and taken away 'for firewood'. On 19th October deputy Chief Designer of OKB-1 P. N. Obroobov, having made a visit to the Ministry of Aircraft Industry, broke the news according to which the Government had adopted a decision calling a halt to all work on the '150' aircraft and stipulating that the machine, together with test rigs and design materials, be turned over to higher education institutions.

Between 29th October and 3rd November 1953 Plant No.1 received instructions, according to which the '150' programme was ripped to shreds. The hydro-mechanical control test rig was to be transferred to Pavel O. Sukhoi's OKB-51, the materials on the aircraft and some units went to Andrey N. Tupolev's OKB-156, and all materials, drawings and



The forward fuselage of the '150', showing the 'greenhouse' canopy and the DB-23 dorsal barbette (with no cannons fitted). The aperture ahead of it is for a periscopic gunsight.

reports on the FUGOG-1 system were appropriated by Kartukov's OKB-2.

In December 1953 the '150' aircraft, complete with all documents and equipment, was transferred to the Moscow Aviation Institute (to Chair No.101) as a teaching aid. Sets of drawings were turned over to the design bureaux led by Gheorgiy M. Beriyev and Oleg K. Antonov. In February 1954, following instructions from the Ministry of Aircraft Industry, many materials on the '150' aircraft and its drawings were also sent to Plant No.491, to which the Germans were transferred from the now defunct OKB of Plant No.1.

Thus, the '150' aircraft which fully met the stipulations of the technical requirement failed to proceed any further in its development. It was considered that the successful service introduction of the mass-produced IL-28 tactical bomber and the successful progress of the Tu-16 long-range bomber's State acceptance trials obviated the need for an intermediate-class machine. In addition, in the situation when the Cold War was getting steadily colder, so to say, the introduction of a new heavy aircraft type was considered superfluous.

It should be noted that, despite all this, the work on the development of a jet bomber featuring swept-back wings and the unusual bicycle undercarriage was not wasted. It was used as a basis for the '152' four-engined turbojet-powered passenger aircraft which was built and tested in Eastern Germany shortly thereafter.

'150-R' tactical photo reconnaissance aircraft (project)

In the first quarter of 1951 design work was conducted for the purpose of developing the '150-R' photo reconnaissance aircraft as a derivative of the '150' bomber. Drawings were issued for a full-scale mock-up of the '150-R' and the mock-up itself was built in March, whereupon all further work was discontinued.

The '150' aircraft in detail

Type: Twin-engined medium bomber. The airframe was of all-metal construction. Wide use was made of B-95 duralumin which was a new alloy for that time. The crew comprised five persons.

Fuselage: Monocoque structure of basically circular cross-section featuring a framework with 38 frames, longerons and large stamped skin panels but no stringers. The fuselage featured a rather complex curvilinear shape with a cylindrical section amidships.

The fuselage was built in two sections, with a production break in the common plane of frames 18 and 19, in the area of attachment of the No.3 longeron which carried the main undercarriage unit. The forward fuselage consisted of two parts; the forward part shaped as an ogival rotation body housed a four-seat pressurised cabin. A hermetically sealed rectangular entry hatch was located on the starboard side between frames 7-9. It was rather small because it was located below the fuselage waterline, still it was big enough for a person to pass upright, using a reclining retractable ladder.

Accommodated under a common heavily framed teardrop-shaped canopy were the pilot (captain) in the left-hand seat, the co-pilot/radar operator to starboard, slightly aft of and below the captain (with a somewhat limited field of view) and the aft-facing dorsal gunner. The navigator/bomb-aimer sat in the extreme nose, his station featuring a hemispherical glazing providing excellent forward visibility; a measure of upward and lateral visibility was provided by several glazing panels. The crew cabin was equipped with a gunsight for the pilot (who operated a forward-firing cannon), flight instruments and units of the environmental control system; the rest of the equipment was placed outside the pressure cabin. A chin fairing (dubbed *boro**da*** – 'beard') housed the units and assemblies of a ground mapping radar; the front part of the 'beard' housed two landing lights. The space below the crew cabin was occupied by the nosewheel well.

The nose section contours were blended into the cylindrical centre fuselage section further aft measuring some 7 m (23 ft) in length and 2.7 m (8 ft 10¼ in) in diameter which incorporated the bomb bay. As already mentioned, it was divided amidships by the manufacturing joint. A considerable part of the bomb bay could be occupied by auxiliary built-in kerosene tanks which could be jettisoned in an emergency.

The rear fuselage aft of the cylindrical section tapered from circular cross-section to a vertical oval measuring 0.75 m in width at its junction with the tail turret. The rear pressurised cabin with a lateral access hatch between frames 36-38 accommodated the gunner/radio operator. Like the other crew members, he was provided with an ejection seat.

Wings: Cantilever high-wing monoplane. Sweepback at quarter-chord 35°, aspect ratio 5, taper 1.82; anhedral 0° on the wing centre section (up to rib No.4 on each side) and 1°20' further outboard to the tips, measured on the wing undersurface.

The wings utilised varying airfoil sections distributed along the span. The TsAGI S-10S-9 symmetrical airfoil with a thickness/chord ratio of 11% was used from the wing root to the plane of the engine pylon (rib No.3). Further outboard up to rib No.4, airfoil sections were of shapes transitional to the TsAGI SR-3-12 asymmetrical airfoil with a thickness/chord ratio of 11.75% which was used on the outer wing panels up to the wingtips.

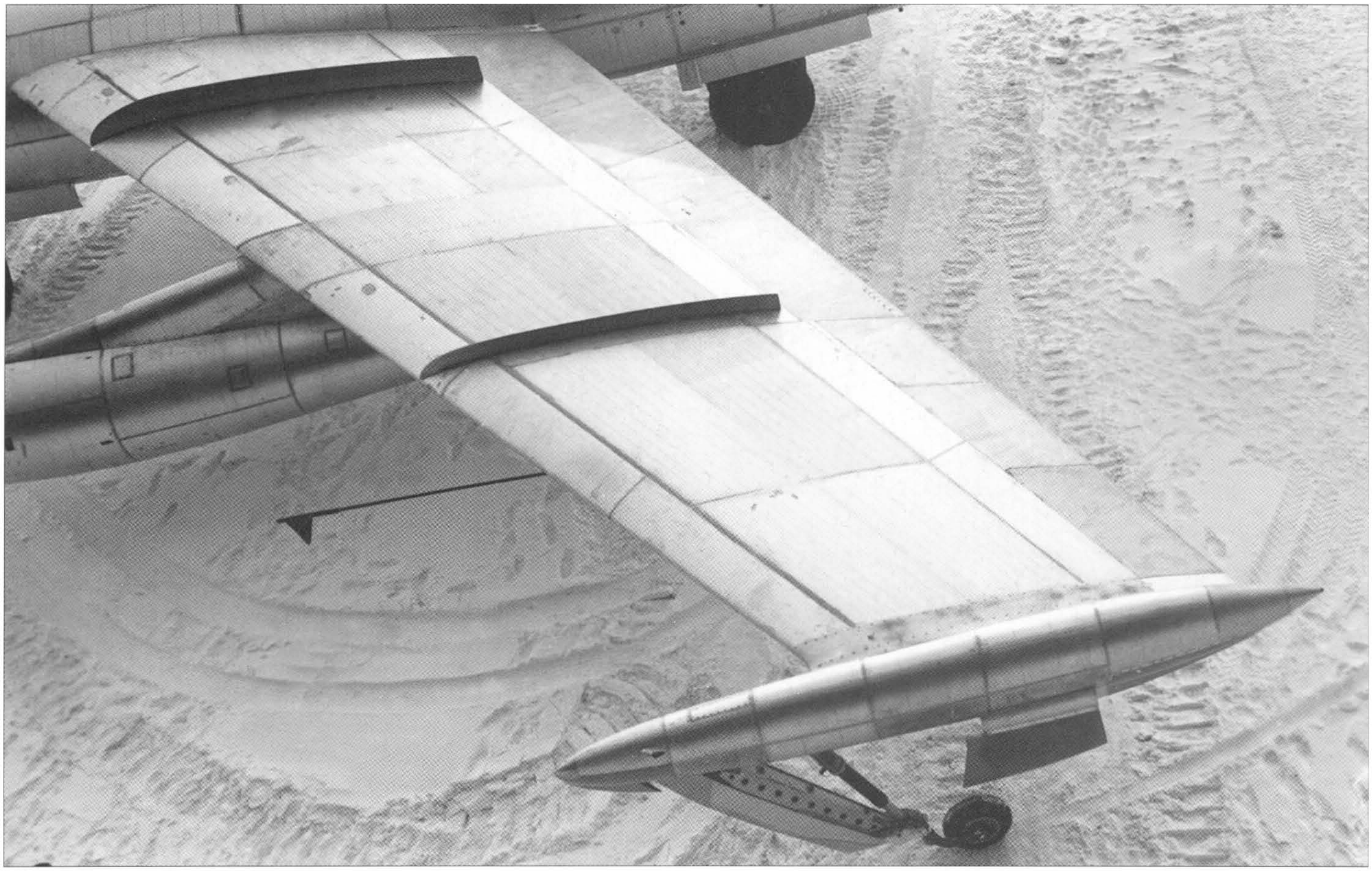
For production reasons the wings were built in four parts. The two halves of the wing centre section with an overall span of 11.5 m (37 ft 8¾ in) were joined together with a flange joint in the aircraft's plane of symmetry (at rib No.1); two detachable wing outer panels were attached to the wing centre section at ribs Nos 4L and 4R. The hermetically sealed inner wing torsion boxes accommodated fuel tanks and were attached to internal members of the fuselage structure above the bomb bay. Two engine pylons were attached by three bolts each to the reinforced ribs Nos 3L and 3R, and the fairings of the outrigger struts were attached by four bolts to the tip ribs (Nos 7L and 7R). Two boundary layer fences were riveted to the wing upper surface in the plane of ribs Nos 2 and 5 (the outer fences were just inboard of the ailerons). The wing skin was reinforced by internal corrugated stiffeners consisting of stamped inverted-U-shaped sections; like the fuselage skin panels, they sustained torsional and bending loads.

The wings' high-lift devices comprised two-section flaps with a total area of 16.4 m^2 (176.3 sq ft); the joint between the sections was located in the area of transitional airfoils and ran at right angle to the flap hinge axes. During take-off and landing the flaps were deflected to an angle of 33° by an electric actuator which was common for both sections; the flaps rotated around a piano hinge rod placed on the wing undersurface.

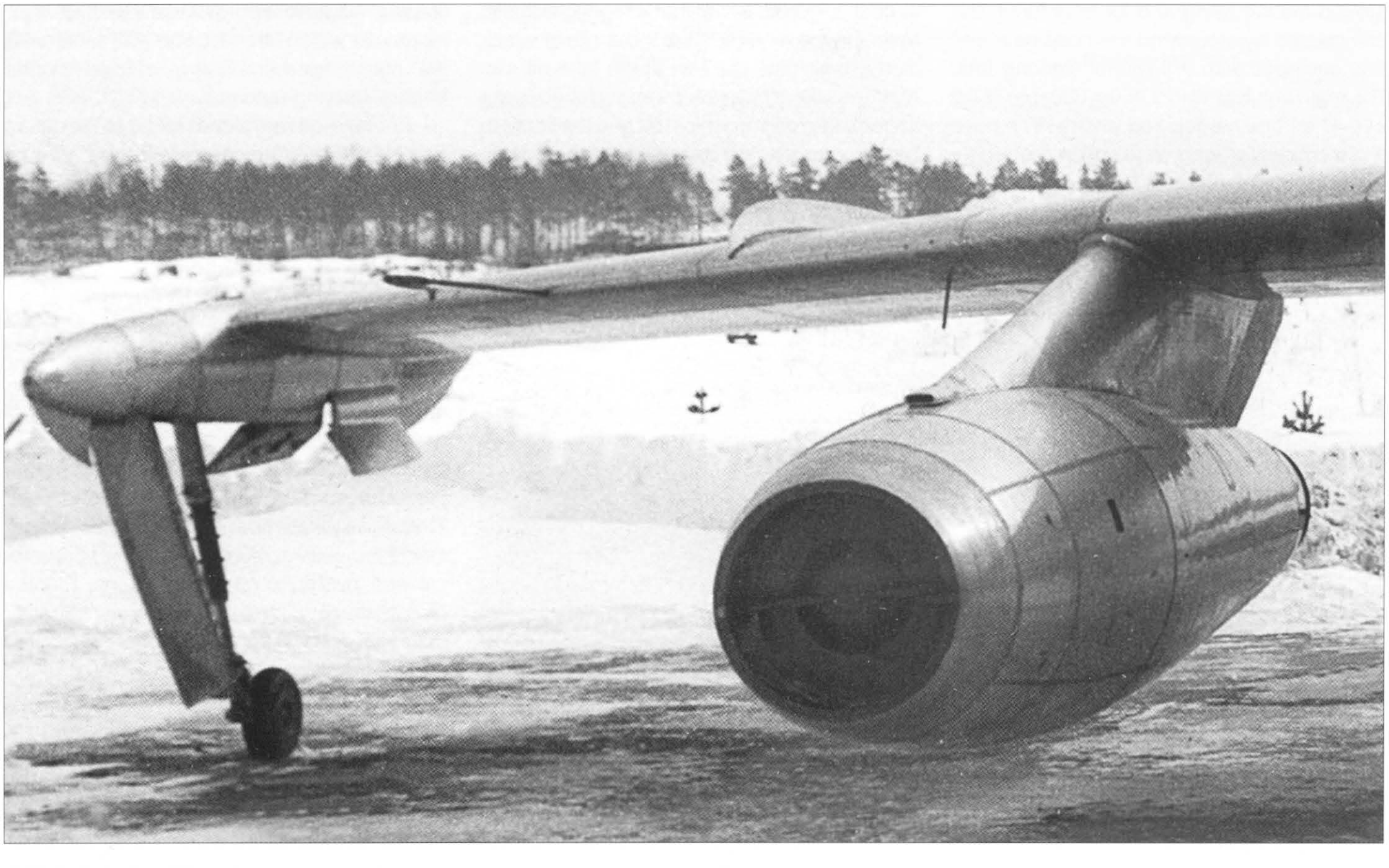
The slotted ailerons were divided into three sections to avoid the jamming of their axles in the suspension bearings due to the bending of the outer wings in flight. The number of sections was arrived at with the help of calculations and graphical methods, and the location of the joints was determined by the distribution of the wing bending places. Dividing movable surfaces into sections enhanced their survivability. The same purpose was pursued by the designers in dividing the tail control surfaces into sections.

Tail unit: Cantilever T-tail. The tail surfaces were structurally very similar to the wings and their high-lift devices. The fin swept back 45° at quarter-chord utilised the TsAGI S-9S-9 airfoil at the root changing into a modified TsAGI airfoil at the top.

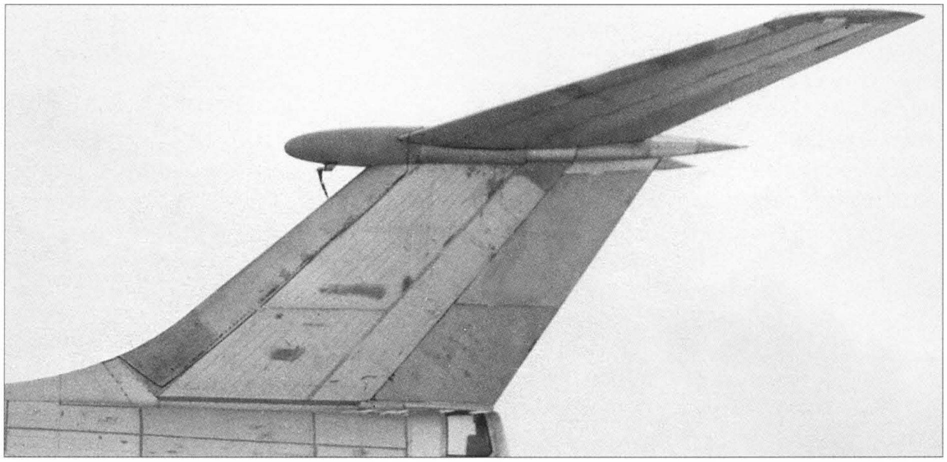
The horizontal tail swept back 40° at quarter-chord had an incidence of +3°30' for longitudinal balancing and 8° dihedral to improve longitudinal controllability at high angles of attack (recommended by TsAGI after wind tunnel tests). The fin/tailplane junction was enclosed by a spindle-shaped fairing placed at a height of 4.5 m (14 ft 9⅛ in) from the fuselage waterline. Its elongated nose



Above: This view shows the wing design of the '150', including the two-section flaps, the three-section ailerons and the outrigger strut fairings doubling as endplates.



This view shows the shape of the engine pylons and engine nacelles. Note that the wingtip pods are effectively underslung.



Above: The tail unit of the '150'; note the two-section rudder. The object under the front end of the fin top fairing may be a mounting bracket for a ciné camera recording the airflow over the wings.

portion provided accommodation for a radio navigation equipment system antenna.

To improve directional stability, two outward-canted strakes were installed under the rear fuselage; this was also a feature prompted by the testing of a scale model of the aircraft in the TsAGI T-101 wind tunnel.

Landing gear: Hydraulically retractable bicycle type with auxiliary outrigger struts located at the wingtips; all units retracted aft. All four units had levered suspension and featured combined actuating rams/shock absorbers.

The nose unit had twin 1,150 x 355 mm (45.27 x 13.97 in) brake-equipped wheels; for ground manoeuvring and for countering the drift caused by crosswind the nose gear unit was equipped with a powerful steering unit. The main unit had twin 1,450 x 520 mm (57.0 x 20.47 in) brake-equipped wheels. The nose and main gear wheels were spaced as widely as possible; the different wheel track on the nose and main units improved the aircraft's ability to operate from unpaved runways with a low bearing strength.

The main unit incorporated a 'kneeling' feature to facilitate the take-off; the 'kneeling' action was effected by the aircraft's own weight. At the end of the take-off run the pilot put the undercarriage control valve into the take-off position, part of the hydraulic liquid was forced out of the cylinder and, after passing through its side nozzles, was drained into the oil tank. The liquid which remained above the piston, occupying 63% of the cylinder's volume, sustained the 'kneeling' aircraft in the right position by applying the working pressure of the hydraulic system which, because of its small volume, earned the name of 'undercarriage hydraulic unit'. Due to the high hydraulic resistance of the nozzles the oil was forced out of the cylinder very slowly and the aircraft lowered its rear fuselage gradually, reaching the required 3° of the angle of attack increase only by the end of the take-off run. After the take off the valve was switched to the 'retraction' position which caused the liquid to be pumped into the space under the piston, while the liquid above the piston was drained completely.

The auxiliary outrigger struts had single 600 x 155 mm (23.62 x 6.10 in) wheels carried on externally mounted half-forks and were hinged ahead of the wingtips in order to place the wheels ahead of the mainwheel axle, thus reducing the arm for turning the aircraft around the outrigger strut pressed to the runway. For this purpose the outrigger struts were provided with long fairings measuring more than 6 m (19 ft).In the course of testing the height of the fairings was increased by extending their lower edges downwards to a wedge shape.

The nosewheel and mainwheel wells were closed by twin doors (the hinges were located externally in the former case and internally in the latter). The outrigger struts had large forward doors enclosing the struts and small twin doors for the wheels.

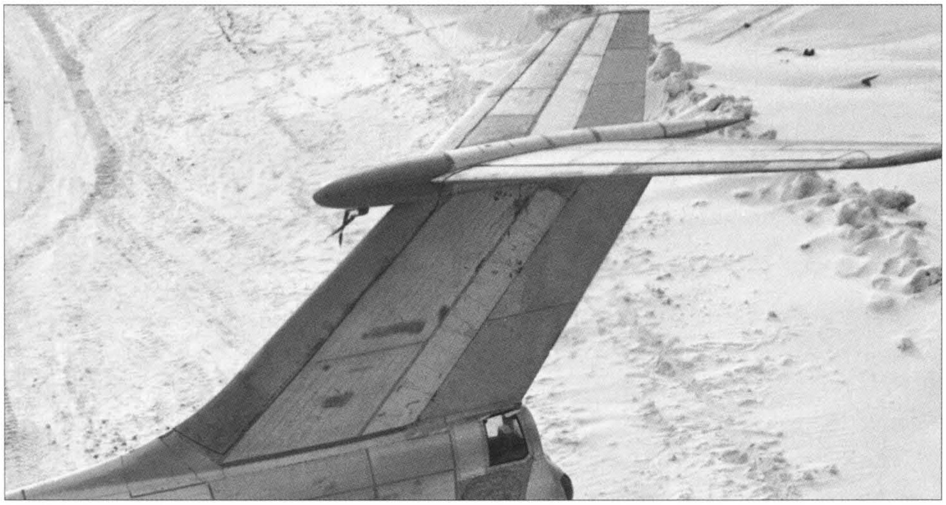
Powerplant: Two Lyul'ka TR-3A (AL-5) axial-flow non-afterburning turbojet engines rated at 5,000 kgp (11,020 lbst) for take-off. The engine had a seven-stage compressor (the inlet guide vanes were referred to as a zero stage), 24 can-type combustion chambers, a variable nozzle and a gasoline turbine starter accommodated in the central fairing of the air intake diffuser.

The engines were mounted in teardrop-shaped nacelles carried under the wings on slender forward-swept pylons. Each engine was placed at a distance from the fuselage which was equal to 26% of the wing half-span; under these conditions a failure of one engine did not create an overly strong yaw. The engine nacelles protruded ahead of the wing leading edge to approximately half of their length. Small 10-litre (2.2 Imp gal) tanks with the starter gasoline were housed in the engine-carrying pylons.

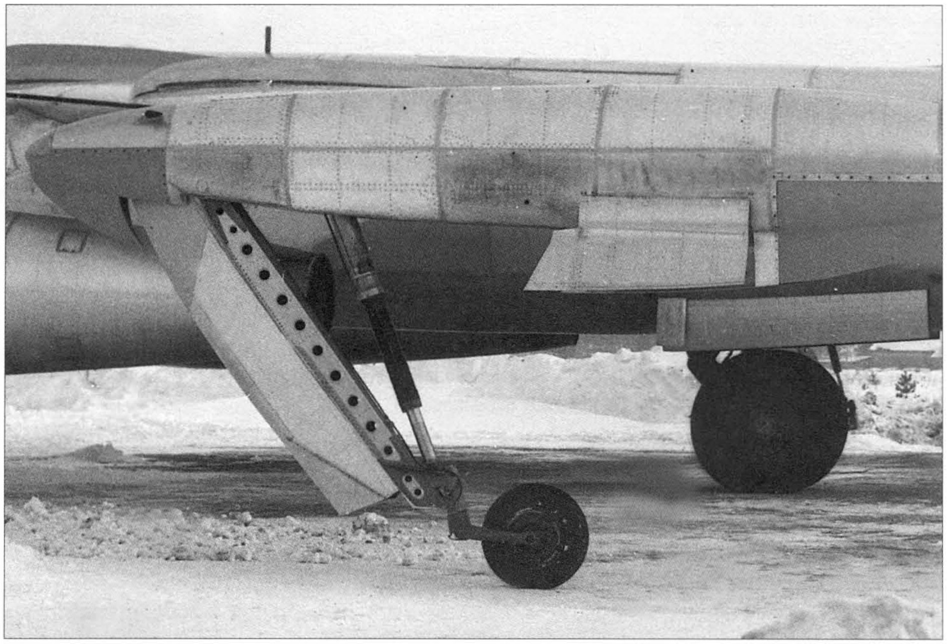
For take-off the aircraft could make use of four '126-1' JATO rockets delivering a thrust of 2,000kg (4,410 lb) each for 17 seconds. JATO rockets of the '129-1' type were used on the prototype.

Control system: Instead of the usual push-pull rods, cables and bellcranks sustaining compression, tension and bending loads, the system was equipped with shafts to which rotating movement was imparted by pairs of coarse-pitch screws driven by independent electric actuators. Electric motors were placed close to the control surfaces and flaps. Their wiring was more convenient for routing inside the units as compared to the mechanical and hydraulic communications. Electric motors actuating the control surfaces received power supply from the powerplant generators.

Fuel system: Eight fuel tanks were permanently located amidships in the fuselage and provided with an emergency fuel jettison system. The tanks had a honeycomb layer for protection against battle damage. The inner surface was partially covered with rubberised



Another view of the tail unit, showing the design of the horizontal tail and the three-piece elevators.



Above: Close-up of the port wingtip fairing (after the modifications intended to improve stability) and the outrigger strut.

fabric and partially varnished. A multitude of small thin-walled duralumin tanks (tubes) manufactured as communicating vessels was placed in a vertical position inside the big tanks. This helped avoid the loss of a large amount of fuel in the event of the tank being pierced by a bullet, because the kerosene would run out of the space between the tubes but remain in the tubes in considerable quantities. All tanks were filled by gravity through overwing fillers. The fuel was also housed in three hermetically sealed riveted torsion boxes of the wing centre section which were a part of the fuselage and the wing centre section and in three jettisonable tanks suspended in the bomb bay. The normal fuel and oil load was 9,000 kg/11,200 litres (19,845 lb/2,464 Imp gal), the maximum load being 18,800 kg/23,470 litres (41,454 lb/5,163 Imp gal).

Electric system: DC power was provided by two 9-kW engine-driven GSR-9000 generators and by two 12A-30 storage batteries.

Avionics and equipment: The aircraft had a ground-mapping radar whose antenna was covered from beneath by a dielectric fairing. The navigator made use of the OPB-5SN bombing sight with the AP-5 directional gyro for bombing against stationary and moving targets from horizontal flight. The dorsal gunner seated in the forward crew cabin was to make use of a PSP-150 flexible periscopic sight (*pri**tsel** strel**kovyy** perisko**pich**eskiy*); a German PVE-8 periscopic sight was used temporarily. The gunner in the rear turret used the PSK-81 collimating sight. The PSBN-M sight was used for bomb-aiming.

The avionics comprised an RSIU-3 VHF radio, an RSB-5 transmitter, an SPU-5 intercom, an ARK-5 automatic direction finder, RV-2 and RV-10 radio altimeters, Bariy-M and Magniy IFF transponders and an SP-50 Materik instrument landing system. An electric autopilot was used during the cruise flight towards the target area.

The aircraft was equipped with a camera container which could carry AFA-33/50 or AFA-33/75 or AFA-33/100 cameras for daytime vertical photography, or NAFA-3S/25, or NAFA-35/50, or NAFA-MK cameras for nighttime photography, and an AFA-BA-40 camera for oblique photography.

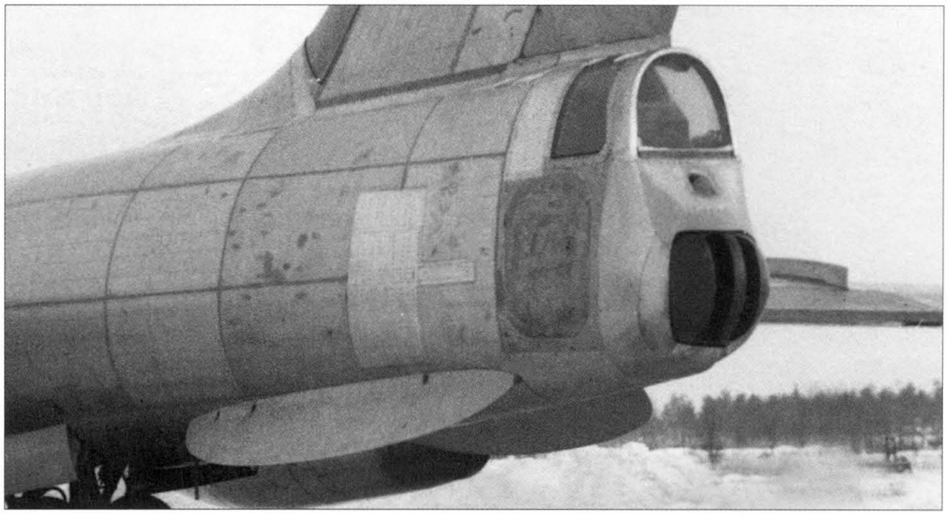
Oxygen equipment: To provide the crew with oxygen, KP-18 and KP-14A (or KP-16A) oxygen regulators were used.

Armament: The defensive armament comprised a fixed forward-firing 23-mm (.90 calibre) Shpital'nyy Sh-23 cannon with 100 rounds placed on starboard side of the forward fuselage, a DB-23 remote-controlled dorsal barbette with two flexible Sh-23 cannons affording a wide angle of fire for protection from the rear hemisphere (if the tail surfaces happened to be on the sighting line a special device interrupted the fire without impeding the controlling movements of the gunner) and the DB-25 tail turret with two flexible Sh-23 cannon. Both barbettes had an ammunition complement of 300 rpg.

A bomb bay capable of housing bombs of different calibre with a total weight of 1,500-6,000 kg (3,310-13,230 lb) was located in the centre fuselage. The bomb complement could vary, depending on the mission; it is detailed in the table below.

The bomb load options of the '150' aircraft

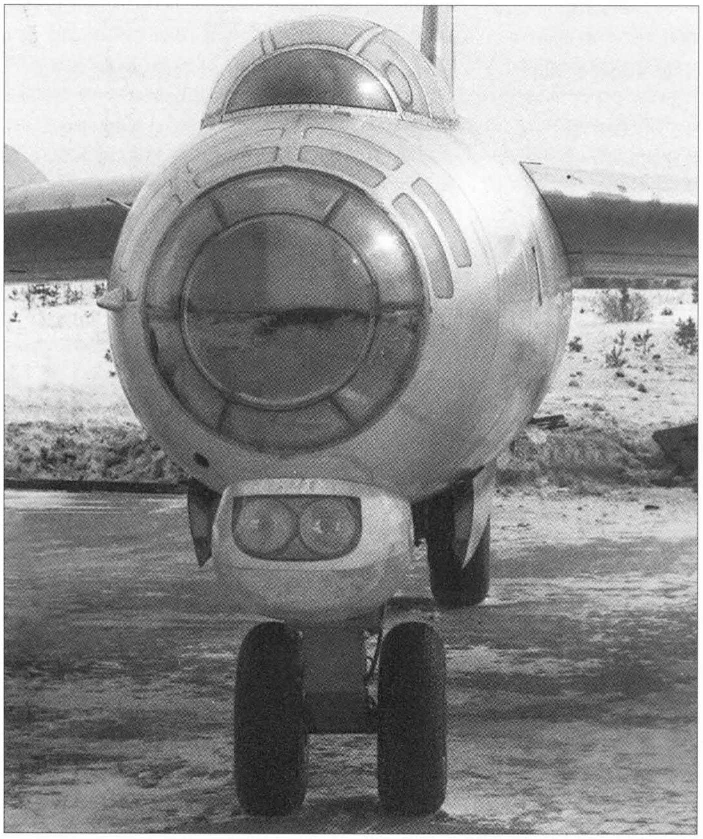
Normal load		Maximum load	
Bomb calibre, kg (lb)	**Total weight, kg (lb)**	**Bomb calibre, kg (lb)**	**Total weight, kg (lb)**
1 x 1,500 (3,307)	1,500 (3,307)	1 x 3,000 (6,615)	3,000 (6,615)
3 x 500 (1,102)	1,500 (3,307)	1 x 1,500 (3,307)	3,000 (6,615)
6 x 250 (551)	1,500 (3,307)	12 x 500 (1,102)	6,000 (13,230)
6 x 100 (220)	600 (1,323)	18 x 250 (551)	4,500 (9,920)
		18 x 100 (220)	1,800 (3,970)



Close-up of the tail gunner's station, showing the DB-25 tail turret, the rear bulletproof glazing panel, the port side access hatch and the jettisonable ventral hatch for the ejection seat.

Dimensions of the '150' aircraft

Length overall	26.74 m (87 ft 8¾ in)
Height on ground	7.6 m (24 ft 11¼ in)
Fuselage cross-section, m^2 (sq ft)	5.73 (62)
Fuselage width	2.7 m (8 ft 10¼ in)
Wing span	24.1 m (79 ft 1 in)
Wing area, m^2 (sq ft)	158.0 (1,700)
Relative area of ailerons	4.9% of wing area
Relative area of flaps	14.25% of wing area
Sweepback at quarter-chord	35°
Wing incidence	3.5°
Stabiliser span	7.56 (24 ft 9⅝ in)
Relative stabiliser area	3.91% of the wing area
Total horizontal tail area, m^2 (sq ft)	16.0 (172)
Relative area of elevators	25.7% of the stabiliser area
Stabiliser mean aerodynamic chord	2.248 m (7 ft 4½ in)
Stabiliser sweepback at quarter-chord	40°
Stabiliser incidence	3.5°
Relative area of the fin	15% of wing area
The fin's height over the fuselage waterline	4.318 m (14 ft 2 in)
Fin mean aerodynamic chord	4.113 m (13 ft 6 in)
Relative area of the rudder	20% of fin area
Total vertical tail area, m^2 (sq ft)	17.2 (185)
Fin sweepback at quarter-chord	45°
Rudder sweepback	38.5°
Distance between engine axes	10.2 m (33 ft 5½ in)
Length of engine nacelles	6.639 m (21 ft 9⅝ in)
Length of outrigger strut fairings	6.05 m (19 ft 10⅛ in)
Width of outrigger strut fairings	0.5 m (1 ft 7⅝ in)
Height of outrigger strut fairings	0.8 m (2 ft 7½ in)
Landing gear track	23.6 m (77 ft 5 in)
Landing gear wheelbase	10.2 m (33 ft 5½ in)



Close-up of the forward fuselage, showing the design of the navigator's station glazing. Note the direct vision window in the cockpit canopy.

Performance of the '150' aircraft (manufacturer's tests)

Engines	TR-3A (AL-5)
Take-off thrust, kgp (lbst)	2 x 5,000 (11,025)
Top speed, km/h (mph):	
at sea level	790 (491)
at 4,500-5,000 m (14,760-16,400ft)	970 (603)
at 10,000 m (32,800 ft)	930 (578)
Landing speed, km/h (mph)	215 (134)
Time to altitude, minutes:	
to 5,000 m (16,400 ft)	5.0/8.0*
to 10,000 m (32,800 ft)	18.0/25.0*
Climb rate, m/sec (ft/min):	
at sea level	18.5/15.5 (3,642/3,051) †
at 5,000 m (16,400ft)	14.0/10.5 (2,756/2,067) †
at 10,000 m (32,800 ft)	6.0/3.0 (1,181/591) †
Service ceiling, m (ft)	12,500/11,500 (41,000/25,360) †
Range, km (miles)	4,500 (2,800)
Endurance, hours	5.6
Take-off run, m (ft)	1,200 (3,940)
Landing run, m (ft)	750 (2,460)
Empty weight, kg (lb)	26,100 (57,550)
Take-off weight, kg (lb):	
normal	37,500 (82,690)
maximum	47,000 (103,635)
Landing weight, kg (lb)	32,000 (70,560)
Wing loading, kg/m^2 (lb/sq ft):	
normal	327 (67)
maximum	407 (83)
Thrust loading, kgp/kg (lbst/lb)	0.21
Fuel and oil load, kg (lb):	
normal	9,000 (19,845)
maximum	18,000 (39,690)
Fuel capacity, litres (Imp gal):	
normal	11,200 (2,464)
maximum	23,470 (5,163)
Bomb load, kg (lb)	1,500-6,000 (3,310-13,230)
Cannon armament, mm (calibre)	5 x 23
Crew	5

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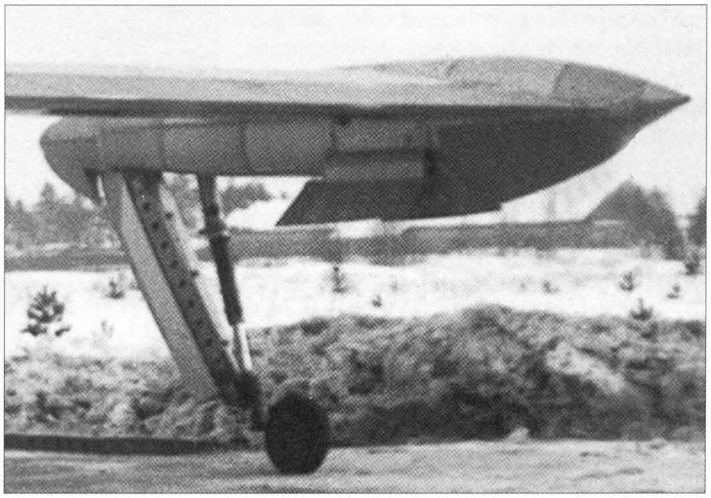
* with normal and overload flight weight

† Rate of climb and service ceiling have been calculated for an average AUW in the normal and overload variants



This view shows the inboard face of the wingtip fairing.

Chapter 6

Tupolev's Early Jets

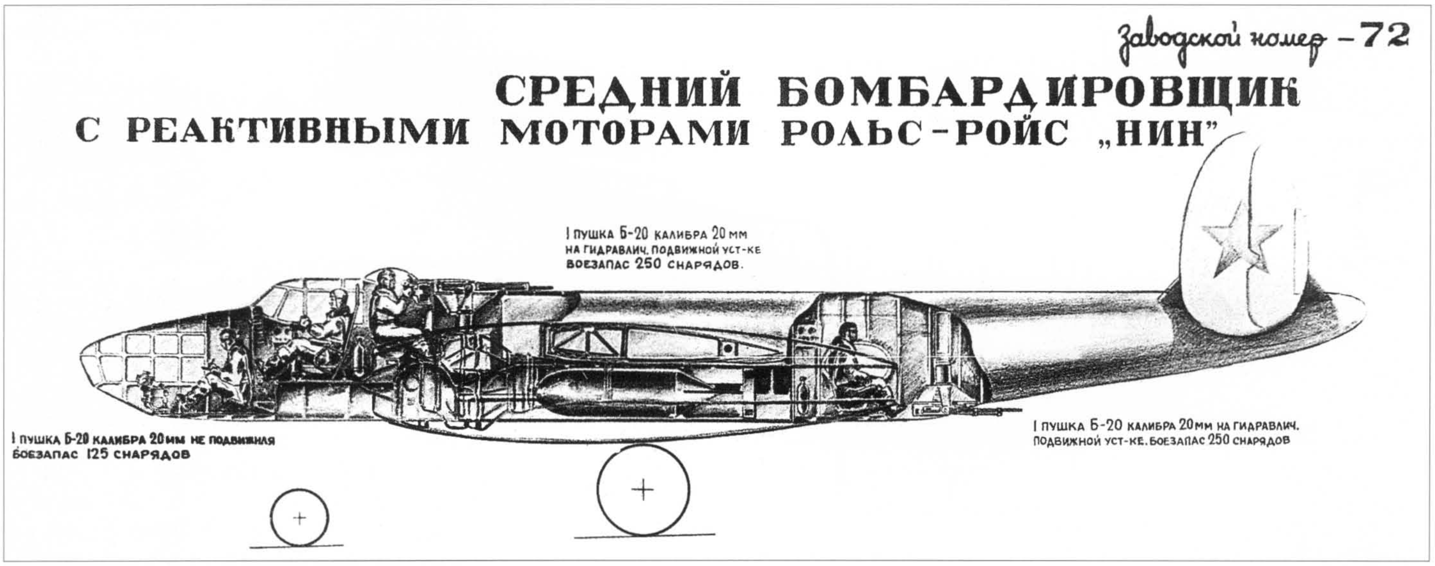
'Aircraft 72' (Tu-18 2 Nene-1) medium bomber project

As already mentioned, the creation and service entry of the first Soviet jet fighters was logically followed by the development of light and medium jet bombers. On 9th April 1946 the Soviet Council of People's Commissars issued directive No.718-318 tasking OKB-156 headed by Andrey Nikolayevich Tupolev with developing a twinjet bomber. This document kicked off the development of two bomber projects which bore the internal designations '72' and '73' respectively; both aircraft were to be powered by two imported Rolls-Royce Nene I centrifugal-flow turbojets rated at 2,270 kgp (5,000 lbst).

The Tupolev OKB gained its first experience with jet propulsion in 1946 when the first Soviet flying testbed for turbojet engines was created jointly with the Flight Research Institute (LII). The engine testbed was developed in keeping with MAP order No.589 of 30th August 1946 which required OKB-156 to prepare all necessary technical documents and convert a production Tu-2 bomber for testing and refining the RD-10 and RD-20 turbojets – the first jet engines to enter production in the USSR. The entire set of documents was to be delivered to MAP aircraft factory No.23 in Fili, then a Western suburb of Moscow (now long since part of the city), which was to convert five production Tu-2S bombers by 10th January 1947. The first of these, an aircraft manufactured by plant No.23 (construction number 22/46 – ie, 22nd aircraft in Batch 46), was converted within a very short time frame). Designated Tu-2LL (*le**ta**yuschchaya laboratoriya* – lit. 'flying laboratory'), the testbeds served LII faithfully up to the mid-1950s for testing early Soviet prototype and production turbojets, including the first indigenous afterburning turbojets. (The Russian term *letayuschchaya laboratoriya* is used indiscriminately and can denote any kind of testbed or research/survey aircraft.)

The limited thrust and generally low performance of the RD-10 and RD-20 (notably the high specific fuel consumption) rendered them an inefficient powerplant for the new post-war bombers. Andrey N. Tupolev and his colleagues were reluctant to use these engines, as the clusters of low-powered but thirsty engines (an inevitable measure in order to obtain the required thrust) would spoil the aircraft's lift/drag ratio and reduce the payload and range. While Tupolev was famed for his conservatism, he was no retrograde. Indeed, he was extremely rational in his approach to aircraft design and, rather than try to squeeze another 100 km/h of maximum speed out of an aircraft by whatever means were at hand, he chose to wait until better engines became available to let him achieve the desired result with fewer losses. Thus, when several dozen RR Nene I engines were imported from the UK, Tupolev immediately set to work on jet bombers with typical gusto.

In 1947 OKB-156 began development of the '72' medium bomber which was also known under the provisional service designation Tu-18 2 Nene-1 (*sic*). (It should be noted here that in the pre-war, wartime and early post-war years it was common practice in the Soviet Union to quote the number and type of engines in the aircraft's official designation, since the same basic design could have versions powered by different engines. In so doing the figure denoting the number of engines (on a multi-engine aircraft) was usually 'lumped together' with the engine's designation – for instance, SB 2M-100A, PS-9 2M-17 etc.). The '72' was derived from the wartime '69' (aka Tu-8) bomber project – a spin-off of the Tu-2 – by substituting the two Shvetsov ASh-82FN radial engines with Nene Is. Another major change was the switch from a tailwheel landing gear to a tricycle gear, the nose unit retracting aft and the main units forward into the engine nacelles, the single wheels turning through 90° to lie flat beneath the engine jetpipes. The latter feature later found use on all aircraft of the Tu-14 family and acquitted itself well. The engine nacelles adhered directly to the underside of the wings and featured a pronounced 'waist' at the joint to minimise harmful interference; this was one of the first instances when the area rule found


Заводской номер –72
СРЕДНИЙ БОМБАРДИРОВЩИК
С РЕАКТИВНЫМИ МОТОРАМИ РОЛЬС-РОЙС „НИН"
I ПУШКА Б-20 КАЛИБРА 20 ММ
НА ГИДРАВЛИЧ. ПОДВИЖНОЙ УСТ-КЕ
БОЕЗАПАС 250 СНАРЯДОВ.
I ПУШКА Б-20 КАЛИБРА 20 ММ НЕ ПОДВИЖНАЯ
БОЕЗАПАС 125 СНАРЯДОВ
I ПУШКА Б-20 КАЛИБРА 20 ММ НА ГИДРАВЛИЧ.
ПОДВИЖНОЙ УСТ-КЕ. БОЕЗАПАС 250 СНАРЯДОВ

An early cutaway drawing of the Rolls-Royce Nene-powered medium bomber which became the Tu-12. The inscription 'zavodskoy nomer – 72' in the upper right-hand corner is misleading, since actually it means not 'construction number 72' but 'manufacturer's designation [Type] 72'!

Basic specifications of the '72' (Tu-18 2 Nene-1)

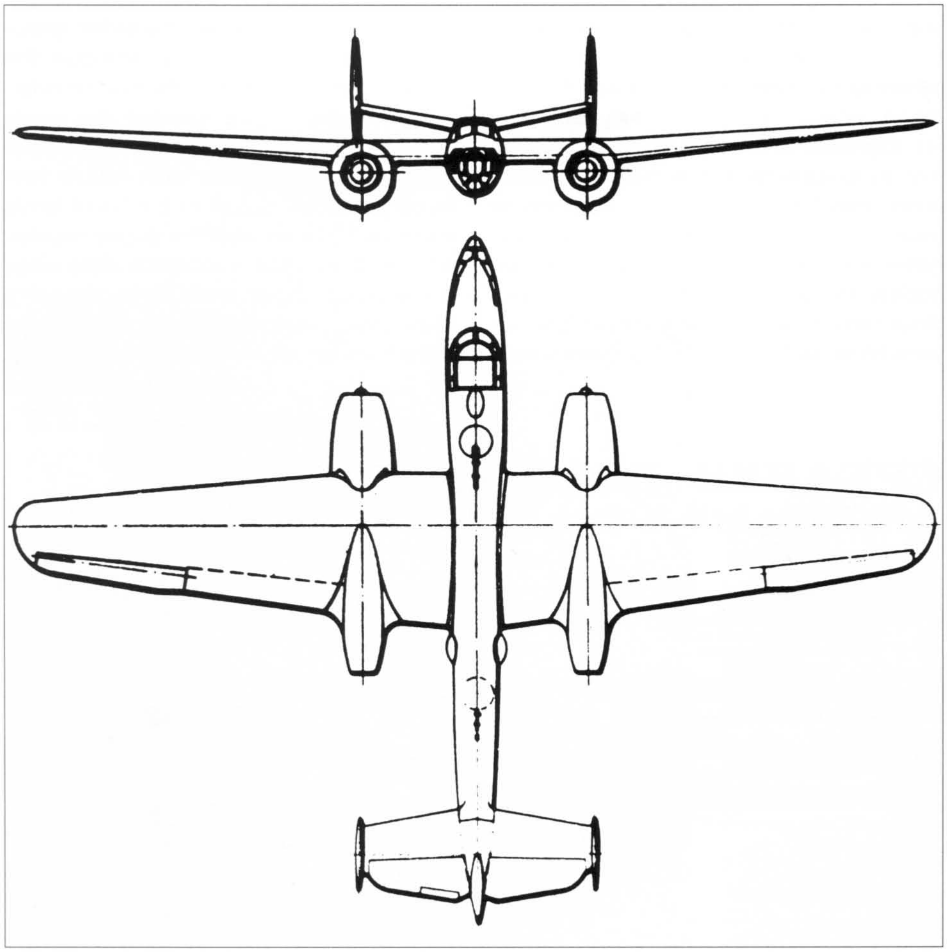
Wing span	22.06 m (72 ft 4½ in)
Length overall	16.11 m (52 ft 10¼ in)
Wing area	61.26 m² (658.7 sq ft)
Maximum speed	725-750 km/h (450-465 mph)
Maximum range with 1,000 kg (2,205 lb) of bombs at 7,500 m (ft)	2,000 km (1,240 miles)
Service ceiling	12,000 m (39,370 ft)
Bomb load:	
normal	1,000 kg (2,205 lb)
maximum	4,000 kg (8,810 lb)

practical application on fast jets; again, this feature was used on all subsequent Tupolev bomber projects from the '73' to the '87' inclusive.

The offensive armament was identical to that of the Tu-8. The defensive armament was very similar as well, comprising a fixed forward-firing Berezin B-20 cannon with 125 rounds plus dorsal and ventral hydraulically powered barbettes, each with a single B-20 and 250 rounds, to cover the rear hemisphere. Unlike the Tu-8, however, the dorsal barbette was operated by a dorsal gunner who sat in a separate pressurised compartment with a dorsal observation/sighting blister; the ventral barbette was still aimed by the gunner/radio operator. Taking into consideration the shorter duration of the flight (due to the jet bomber's higher speed), the crew was reduced to four by eliminating the co-pilot and the cockpit was redesigned accordingly.

Development of the '72' was abandoned at the technical proposal stage because OKB-156 started work on the more promising '73' bomber project. The basic specifications of the '72' (Tu-18 2 Nene-1) are set out in the table at the top of this page.

Before the '72' was terminated the engineers briefly considered a cross-breed between it and the '73' – a combination of the latter aircraft's fuselage with the wings and engine nacelles of the '72'. The most unusual feature of this project configuration was the use of a swept butterfly tail.



A project drawing of the '72' jet bomber. The aircraft's Tu-2 ancestry is obvious.

'Aircraft 77' (Tu-30 4 Nene-1) medium bomber project

Concurrently with the projects of the piston-engined Tu-26 2 M-3 and Tu-28 2 M-3 bombers the Tupolev OKB offered the Air Force to design a medium bomber powered by four Rolls-Royce Nene I turbojets. The project received the in-house designation '77' (Tu-30 4 Nene-1).

The OKB completed preliminary design studies, determining the bomber's main dimensions, and completed a so-called tactical model (ie, desktop model). The aircraft bore more than a passing resemblance to the North American B-45 Tornado, the engines being housed side by side in flattened nacelles adhering to the undersides of the shoulder-mounted unswept wings; the latter had a relatively large area, since the '77' was conceived as a high-altitude fast bomber and reconnaissance aircraft. The circular-section fuselage featured a fighter-type bubble canopy for the pilot. Unlike the B-45, which had low-set stabilisers featuring strong dihedral, the '77' had cruciform tail surfaces with zero dihedral. The crew of four was accommodated in three pressurised compartments – forward (comprising the cockpit and the navigator/bomb-aimer's station), centre (the dorsal gunner's station) and rear (the tail gunner's station). The defensive armament consisted of three 23-mm (.90 calibre) Nudelman/ Suranov NS-23 cannons in a fixed forward-firing installation, a dorsal barbette just aft of the wing trailing edge and a tail turret.

According to the OKB's technical proposal the aircraft was to enter State acceptance trials in June 1948 and was expected to have the following specifications:

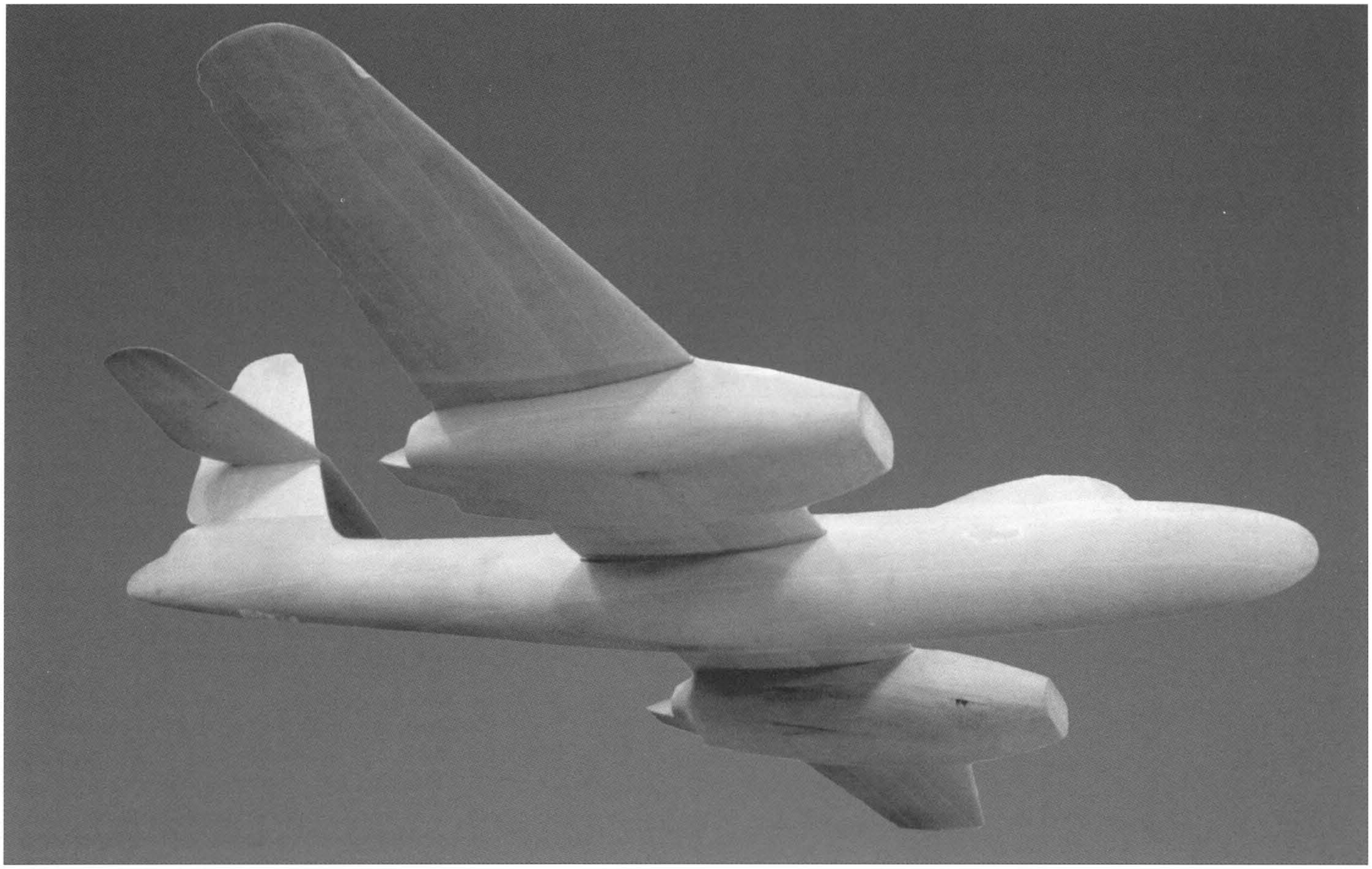
Wing span*	26.5 m (86 ft 11⅜ in)
Length overall*	19.5 m (63 ft 11¾ in)
Height, fuselage horizontal*	5.5 m (18 ft ½ in)
Wing area*	110 m² (1,182 sq ft)
Maximum speed:	
at sea level	725 km/h (450 mph)
at 6,000 m (19,685 ft)	800 km/h (496 mph)
Service ceiling	11,500 m (37,730 ft)
Maximum range with 1,000 kg (2,205 lb) of bombs	3,000 km (1,860 miles)

* The dimensions were calculated, using a scale model which has survived to this day.

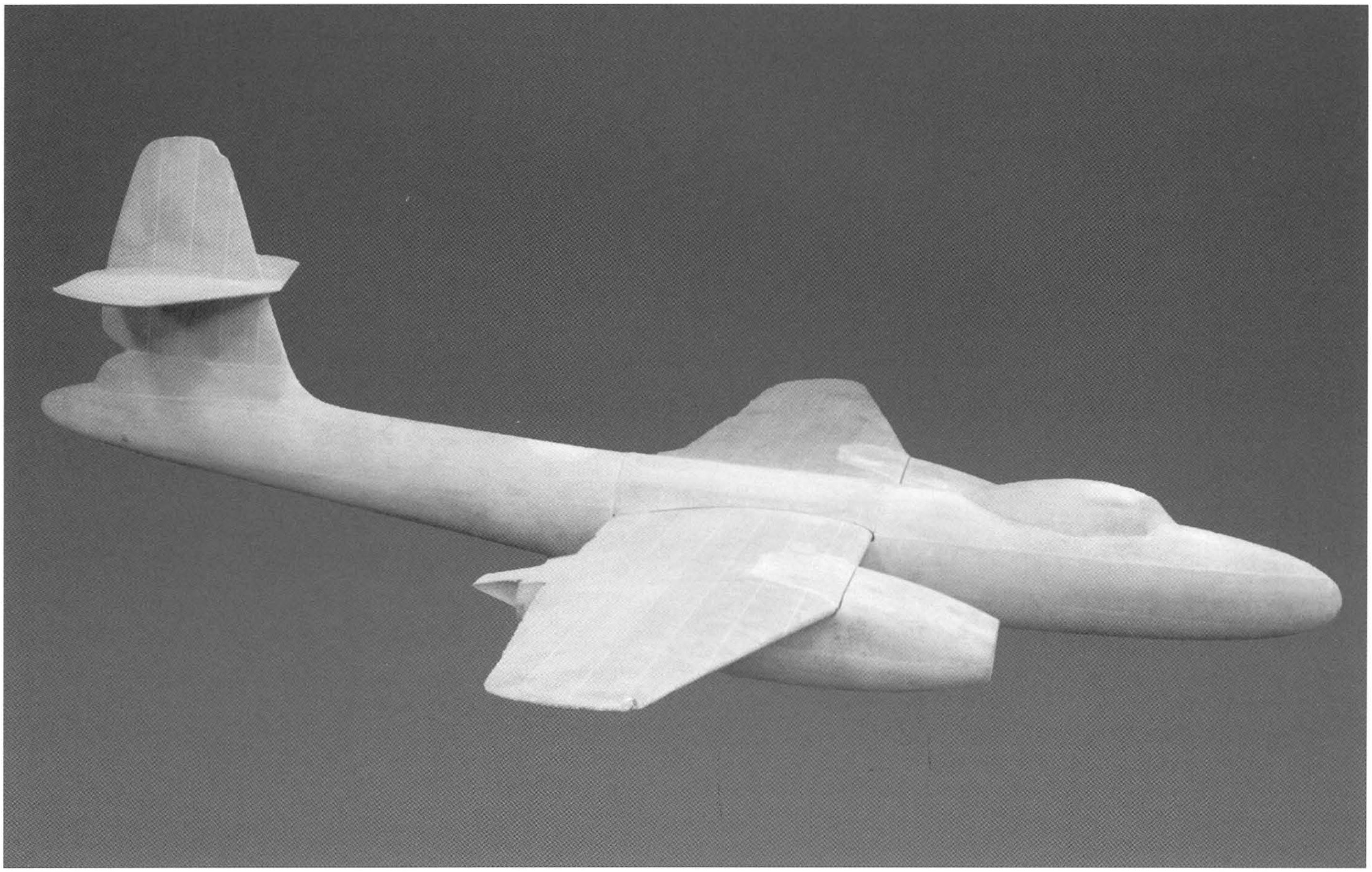
The Tu-30 4 Nene-1 did not progress beyond the technical proposal stage.

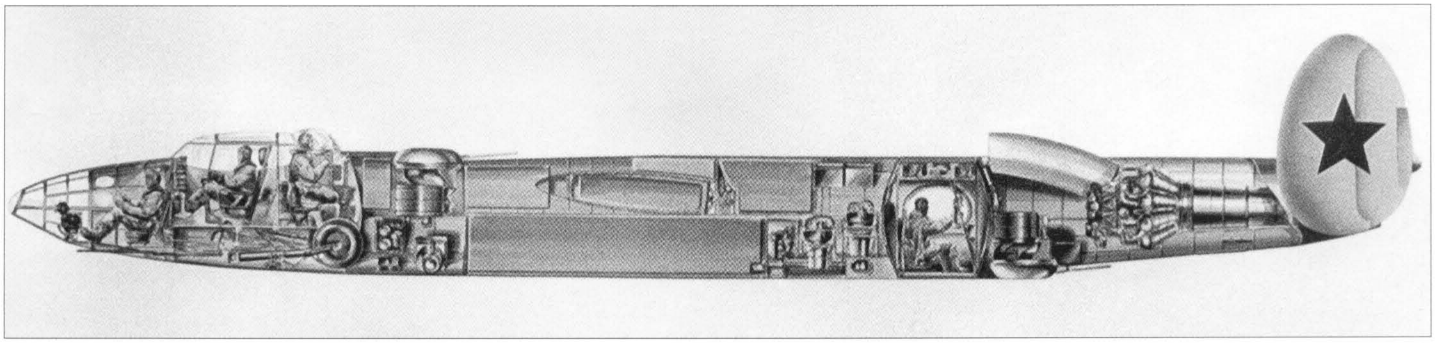
Tu-12 tactical bomber prototype ('aircraft 77', Tu-10)

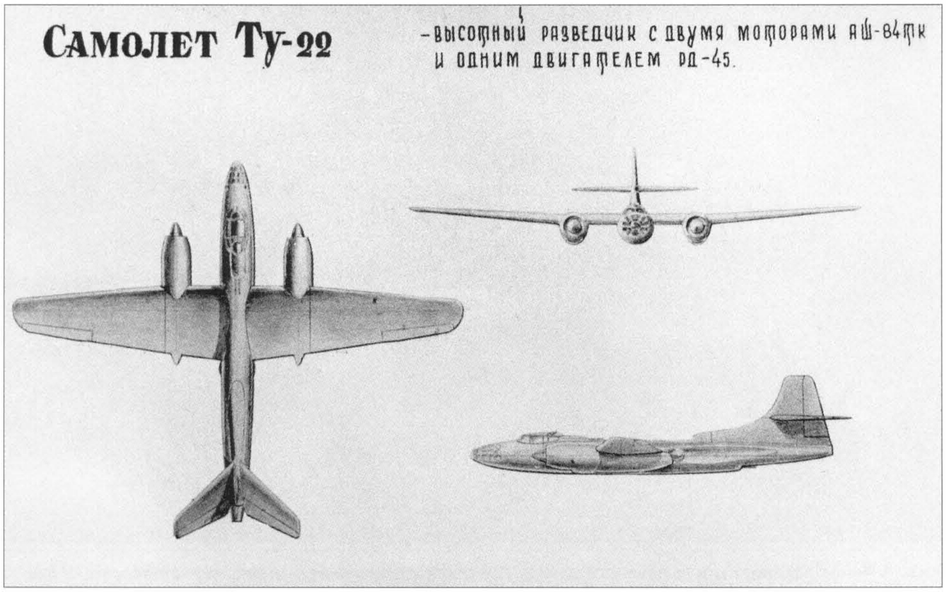
Since early 1947 the Tupolev OKB had been hard at work on the aforementioned project of a tactical bomber powered by two RR Nene Is and bearing the in-house designation '73'.



Above and below: This model illustrates what the '77' (Tu-30 4 Nene-1) bomber would have looked like. The general arrangement is strongly reminiscent of the North American B-45, but the tail unit design is different.



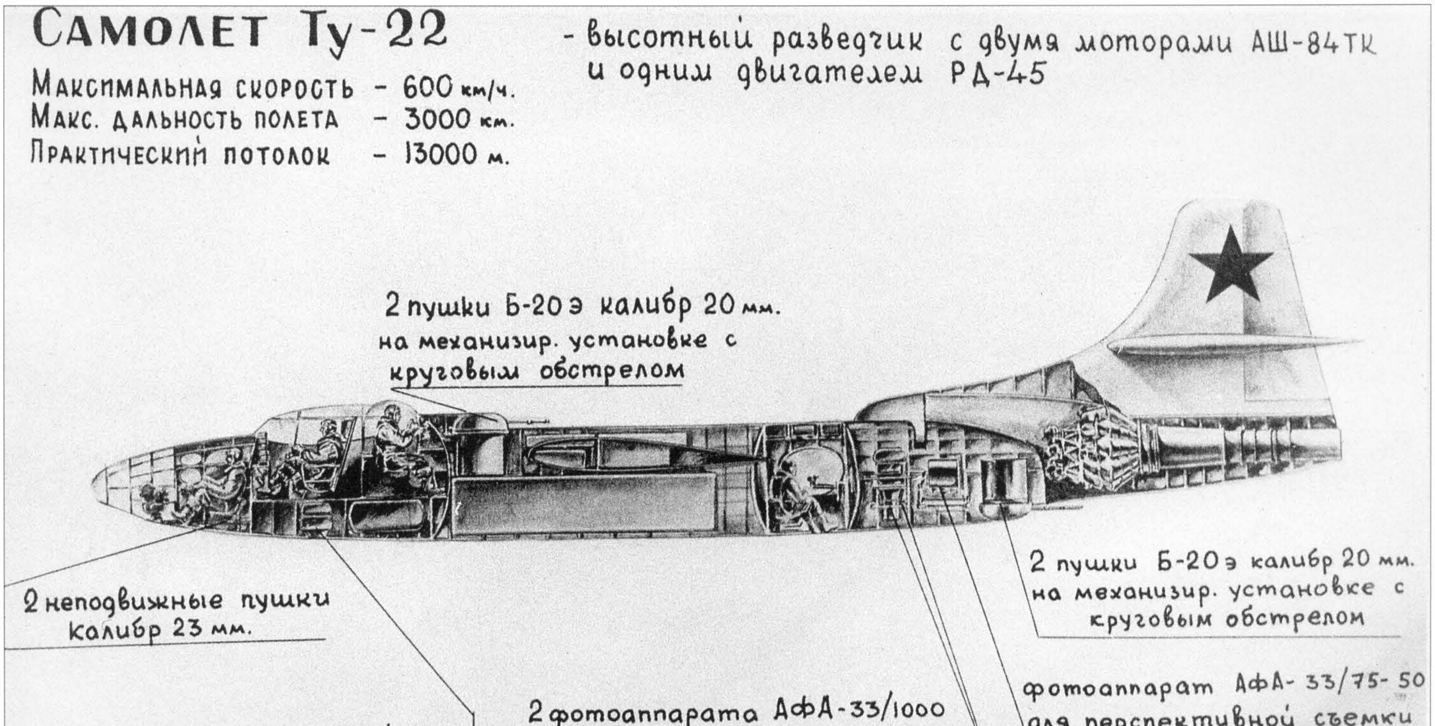



Самолет Ту-22
-высотный разведчик с двумя моторами АШ-84ТК
и одним двигателем РД-45.

Above: A cutaway drawing from the project documents of the '74' (Tu-22) bomber, showing the location of the RD-45 booster engine in the rear fuselage and its air intake design. Note the original twin-fin tail unit taken straight from the Tu-2 series.

Left: A general arrangement of the Tu-22 – the first Tupolev bomber to be thus designated. This was to be a mixed-power aircraft, the main engines being Shvetsov ASh-84TK turbocharged radials. This is a later version of the project featuring a single fin and swept stabilisers; the intake of the booster engine is hidden in the dorsal fin, as would later be done on the '73' jet bomber, and the shape of the tail is very similar, too.

Below: Another cutaway drawing, this time depicting the later version of the '74' (Tu-22). Note that the rear gunner controlling the ventral barbette has a midship pressurised cabin all to himself.

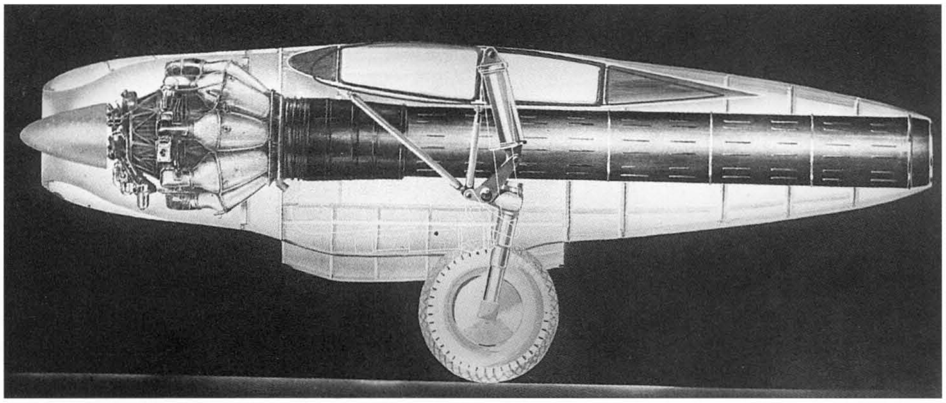

Самолет Ту-22
- высотный разведчик с двумя моторами АШ-84ТК
и одним двигателем РД-45
Максимальная скорость - 600 км/ч.
Макс. дальность полета - 3000 км.
Практический потолок - 13000 м.
2 пушки Б-20э калибр 20 мм.
на механизир. установке с
круговым обстрелом
2 неподвижные пушки
калибр 23 мм.
фотоаппарат АФА-33/200
для плановой съемки
2 фотоаппарата АФА-33/1000
для планово-перспект. съемки
2 пушки Б-20э калибр 20 мм.
на механизир. установке с
круговым обстрелом
фотоаппарат АФА-33/75-50
для перспективной съемки
Гл. конструктор А.Н. Туполев

The intention was to complete the prototype by mid-year so that the aircraft could participate in the annual Aviation Day air fest at Moscow-Tushino airfield attended both by the public at large and the nation's leaders. Yet when the work was well advanced the customer (the Soviet Air Force) reshuffled the cards, placing the '73' in a heavier category – the medium bomber class – and altering the specifications accordingly, particularly as regards range. A thorough redesign had to be undertaken, and the result was to all intents and purposes a new aircraft powered by three engines – two RR Nene Is in underwing nacelles and one RR Derwent V buried in the rear fuselage. The bottom line was that OKB-156 could not possibly complete the new aircraft in time for the parade. Therefore, after conferring with the Air Force, a decision was taken to convert several standard Tu-2 bombers within the shortest possible time and with minimum changes by substituting the Shvetsov ASh-82FN 14-cylinder radials driving four-bladed propellers with Nene I turbojets. While this hybrid was intended primarily as a face-saving device to appease the government, which demanded jet bombers pronto, and escape reprisal for failing to present them on time, the aircraft was to incorporate the design featured developed for Tupolev's first jet bomber projects – the '72' and '73' – to the greatest possible extent.

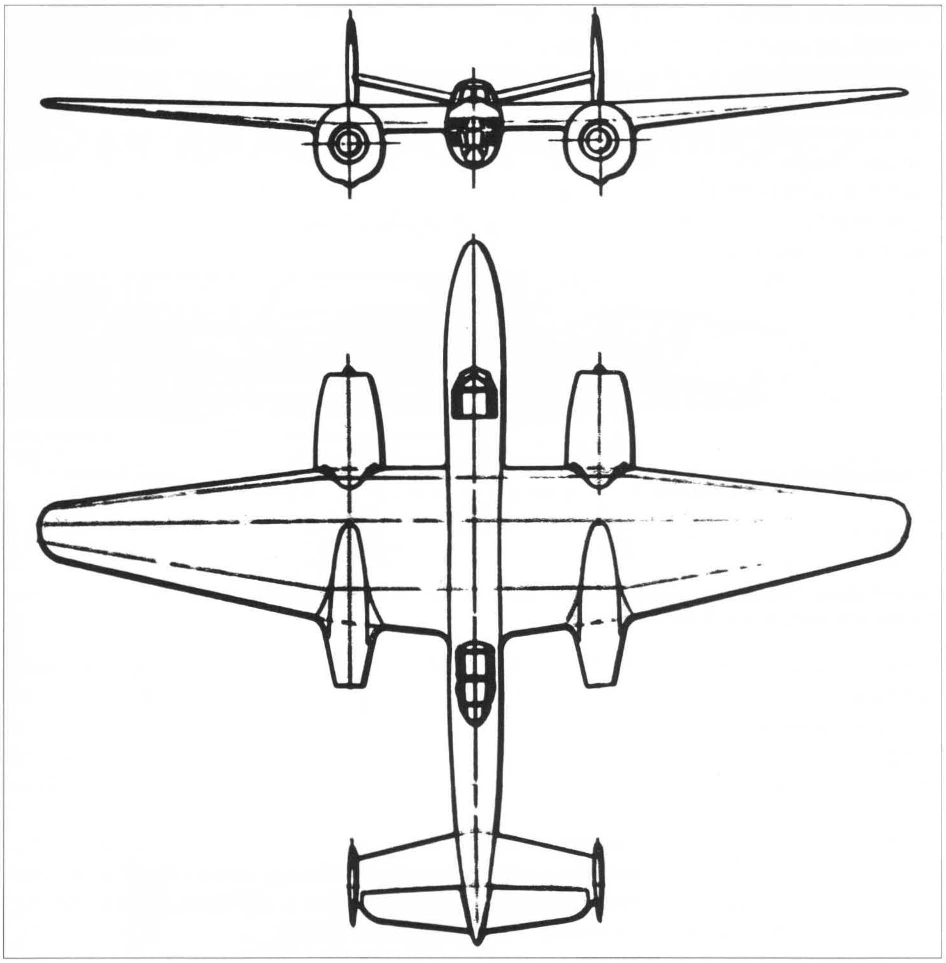
For the outsider, OKB-156 confuses the picture immensely by using the same designations time and again for a number of rather different projects. Thus the new aircraft inherited the manufacturer's designation '77' from the stillborn Tu-30 4 Nene-1 described above and the official designation Tu-18 2 Nene-1 from the '72' project described at the beginning of the chapter; soon, however, the latter designation was changed to Tu-10 2 Nene-1. According to initial calculations, at an all-up weight of 12,700 kg (28,000 lb) the bomber would have basic performance figures as detailed in the table at the foot of the page.

The offensive and defensive armament was specified as follows. The normal bomb load was 1,000 kg (2,205 lb), increasing to 4,000 kg (8,810 lb) in overload configuration. For self-defence the Tu-10 was armed with a pair of forward-firing 20-mm (.78 calibre) Shpital'nyy/Vladimirov ShVAK cannons with 150 rpg, a 12.7-mm (.50 calibre) Berezin UBT machine-gun with 150 rounds on a VUB-2 dorsal mount and a second UBT with 200 rounds on an LU-68 ventral mount to cover the rear hemisphere.

In April 1947 Andrey N. Tupolev approached the government with a proposal concerning the '77' bomber, supporting various purely technical and organisational issues with the argument that his OKB wished to create an interim jet bomber based on the familiar and well-mastered Tu-2. A while earlier



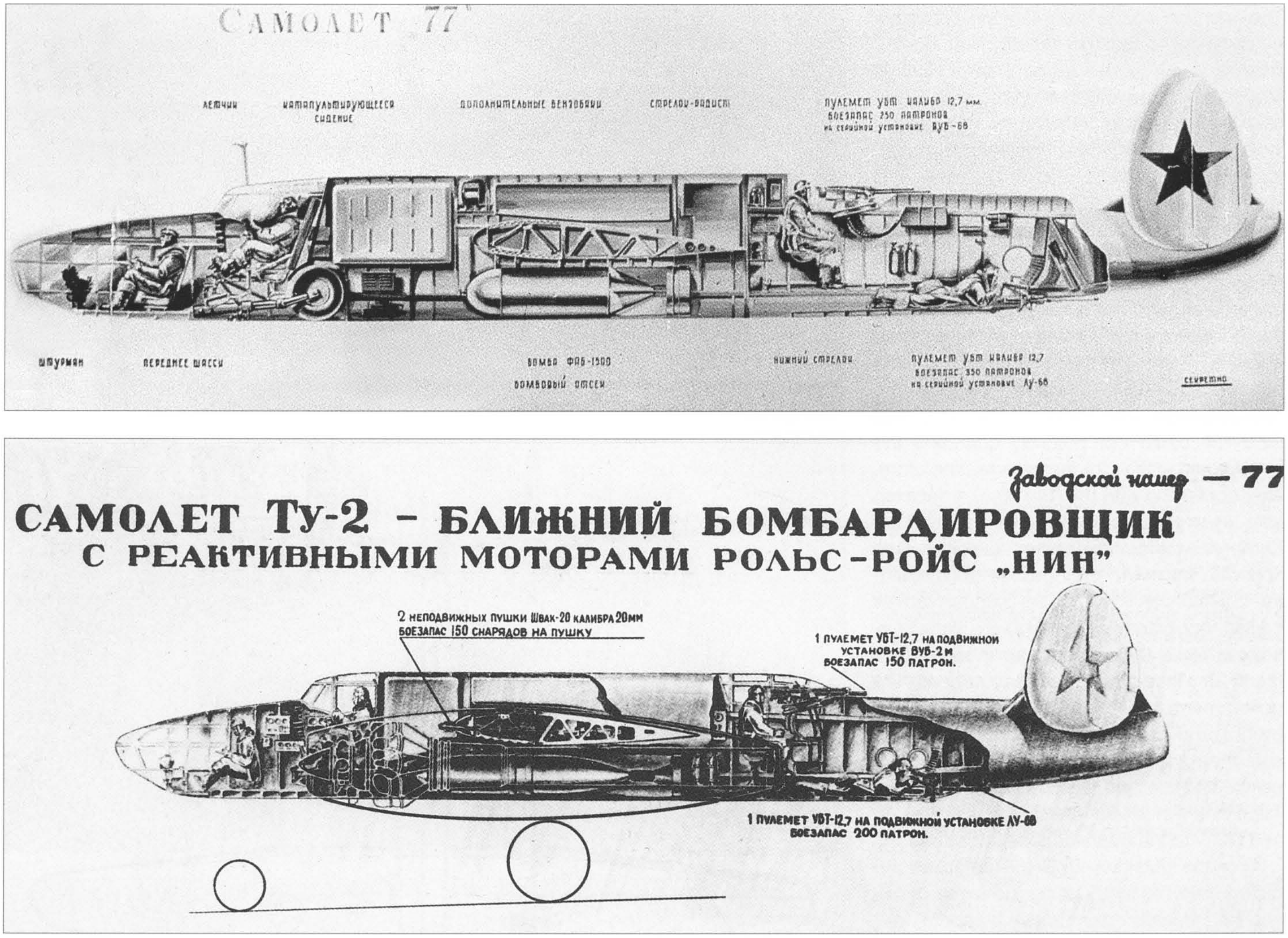
Above: A drawing illustrating the engine nacelle/main landing gear design of the '77' bomber; the wheels stowed below the long extension jetpipes.



An early drawing of the '77' (Tu-12) from the project documents – another iteration of the 'jet Tu-2' theme.

Design performance figures of the '77' (Tu-10 2 Nene-1)

	Target figures	Minimum guaranteed figures
Maximum speed, km/h (mph):		
at sea level	820 (509)	780 (484)
at 6,000 m (19,685 ft)	810 (503)	775 (481)
Climb time to 5,000 m (16,400 ft), minutes	4	5
Service ceiling, m (ft)	13,100 (42,980)	12,000 (39,370)
Take-off run with 15,400-kg (33,950-lb) maximum AUW, m (ft)	1,050 (3,445)	1,200 (3,940)
Landing run with 9,460-kg (20,855-lb) landing weight, m (ft)	420 (1,380)	500 (1,640)
Landing speed with 9,460-kg landing weight, km/h (mph)	130 (81)	150 (93)


САМОЛЕТ 77
ЛЕТЧИК
КАТАПУЛЬТИРУЮЩЕЕСЯ СИДЕНИЕ
ДОПОЛНИТЕЛЬНЫЕ БЕНЗОБАКИ
СТРЕЛОК-РАДИСТ
ПУЛЕМЕТ УБТ КАЛИБР 12,7 мм. БОЕЗАПАС 250 ПАТРОНОВ НА СЕРИЙНОЙ УСТАНОВКЕ ВУБ-68
ШТУРМАН
ПЕРЕДНЕЕ ШАССИ
БОМБА ФАБ-1500
БОМБОВЫЙ ОТСЕК
НИЖНИЙ СТРЕЛОК
ПУЛЕМЕТ УБТ КАЛИБР 12,7 БОЕЗАПАС 350 ПАТРОНОВ НА СЕРИЙНОЙ УСТАНОВКЕ ЛУ-68
СЕКРЕТНО
Заводской номер — 77
САМОЛЕТ Ту-2 - БЛИЖНИЙ БОМБАРДИРОВЩИК
С РЕАКТИВНЫМИ МОТОРАМИ РОЛЬС-РОЙС „НИН"
2 НЕПОДВИЖНЫХ ПУШКИ ШВАК-20 КАЛИБРА 20ММ БОЕЗАПАС 150 СНАРЯДОВ НА ПУШКУ
1 ПУЛЕМЕТ УБТ-12,7 НА ПОДВИЖНОЙ УСТАНОВКЕ ВУБ-2М БОЕЗАПАС 150 ПАТРОН.
1 ПУЛЕМЕТ УБТ-12,7 НА ПОДВИЖНОЙ УСТАНОВКЕ ЛУ-68 БОЕЗАПАС 200 ПАТРОН.

Top and above: Two cutaway drawings of the 'quick fix' Tu-123 ('77'). Interestingly, the caption to the lower drawing refers to the aircraft as a 'Tu-2 short-range bomber with Rolls-Royce Nene jet engines'!

Aleksandr S. Yakovlev had resorted to the same devious trick earlier when promoting his Yak-15 jet fighter which was a direct derivative of the mass-produced piston-engined Yak-3. Still, this approach was justified in that it allowed the Soviet aircraft industry (which was still recovering from the ravages of the war) and the Soviet Air Force to make a relatively smooth transition from prop-driven aircraft to more sophisticated jet hardware.

Tupolev's arguments about the difficulties associated with the all-new '73' bomber fell on sympathetic ears at the top level, and the proposal to build the interim '77' was supported. Not waiting for the government to issue an appropriate directive giving the '77' official status, OKB-156 started work on the advanced development project and began construction of a full-scale mock-up; the former was largely completed and the latter finished in May 1947. On 24th-28th May the Air Force's mock-up review commission examined the mock-up, voicing a few critical comments; the need to eliminate the deficiencies pointed out by the commission caused the completion of the ADP to be somewhat delayed. Meanwhile, not waiting until development of the '77' had been officially ordered and all controversial issues had been sorted out with the customer, OKB-156 started prototype construction in May; the prototype was converted at the OKB's experimental shop (MMZ No.156; MMZ = *Mos**kov**skiy ma**shin**ostro**it**el'nyy za**vod*** – Moscow machinery plant) from a standard Moscow/Fili-built Tu-2S (c/n 16/52).

On 31st May 1947 the Council of Ministers finally gave birth to directive No.1805-476 ordering development of the '77' (Tu-10) bomber, followed by MAP order No.381 to the same effect on 13th June. According to the latter document, the first aircraft was to be completed by MMZ No.156 and delivered in September 1947. A further five Tu-10s were to be remanufactured from production Tu-2Ss directly at plant No.23 in Fili, two of these due for delivery in October 1947 and the other three in December.

The item of the said CofM directive dealing with the '77' (Tu-10) was actually number 2; item No.1 concerned the development and construction of the '73' bomber powered by two RR Nene Is and one RR Derwent V (instead of the bomber's twin-engined version envisaged earlier). Even though no official document expressly required the '77' to be ready for flight testing in time for the Aviation Day air fest in August (as already noted, the official delivery deadline was September), the leaders and entire staff of OKB-156 'read between the lines' and were firmly intent on delivering the prototype in July.

The specifications for the '77' set forth in the Council of Ministers directive basically matched the OKB's own guaranteed figures and were as follows. Top speed was to be 775-800 km/h (481-496 mph), maximum range in optimum cruise mode 1,250 km (776 miles), the normal and maximum bomb load 1,000 and 3,000 kg (2,205 and 6,610 lb) respectively. The defensive armament was specified as one fixed forward-firing NS-23 cannon and two UBT-12.7 machine-guns covering the tail.

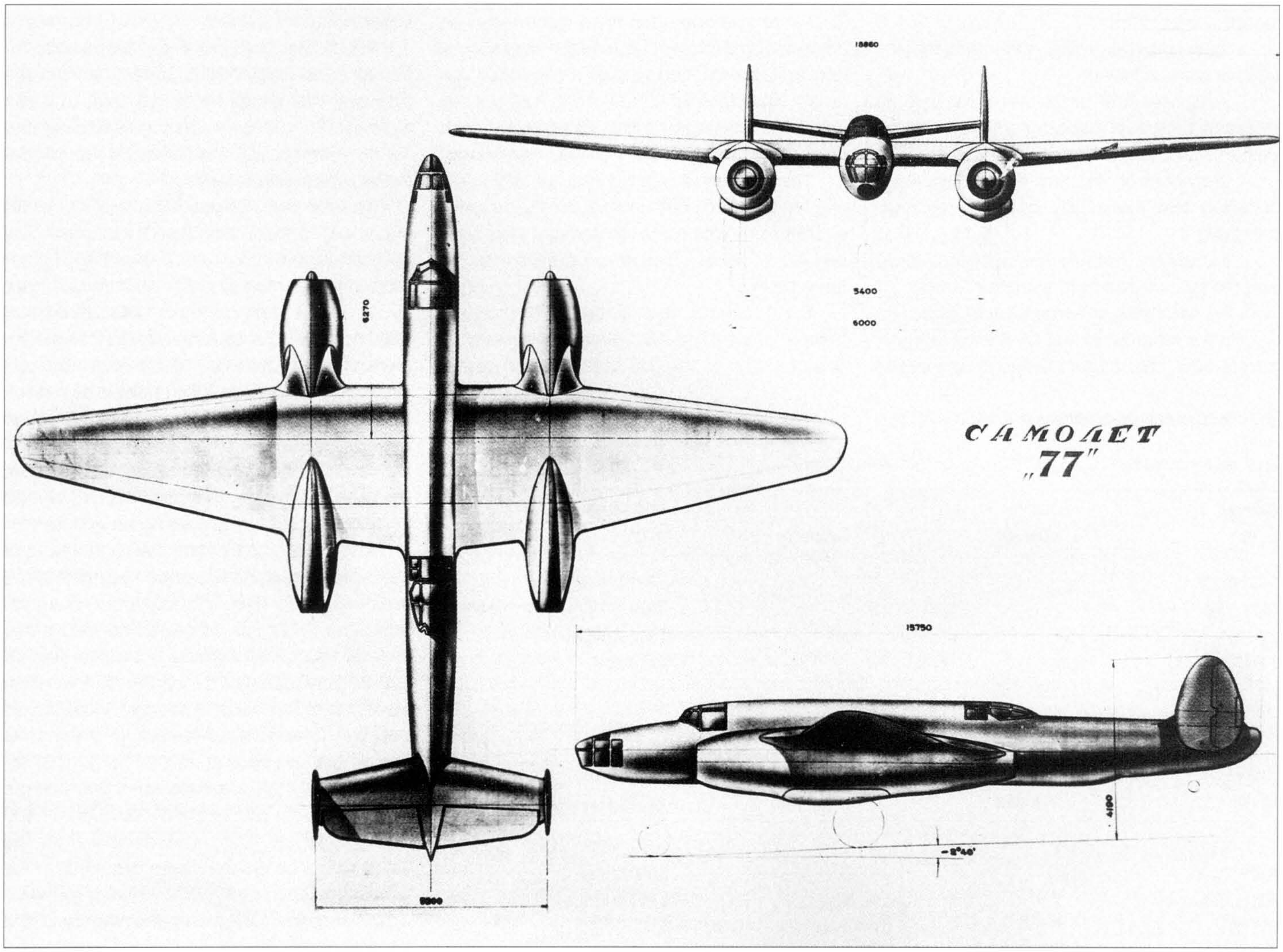
Initially the '77' was the responsibility of OKB-156's technical projects department (PD section) under Sergey M. Yeger. Later, when the work reached the detail design stage, overall responsibility was reassigned to the versions bureau led by Ye. I. Baru and several other design teams; concurrently Baru was appointed the aircraft's project chief. Established in 1945 at Andrey N. Tupolev's orders, the versions bureau co-ordinated the work of OKB-156's design teams on various versions of the Tu-2; later on, it was to do the same with future production Tupolev aircraft.

With the air fest just over three months away, the organisation of the '77' programme at the OKB and at MMZ No.156 required extremely efficient time planning and swift reaction to any problems coming up. The work schedule was planned literally to the day (who says the 'just in time' system is new?), and the work in the design offices and the experimental shop went on around the clock. Delivery dates for this or that chunk of manufacturing documentation were set right down to the hour. For instance, the designers were given a 24-hour deadline to prepare the documents for the changes to the stock Tu-2 fuselage; in the late afternoon the blueprints were already in the assembly shop of MMZ No.156. All drawings and sketches were delivered to the manufacturing department right away and parts manufacture began immediately on receipt. Overall responsibility for the design process, and subsequently for the test and development programme, was assigned to Tu-2 chief project engineer Dmitriy S. Markov. This 'run like hell' method of work made it possible to meet the objective: the '77' prototype was completed by July 1947 and cleared for flight tests, making sure it could take part in the Tushino flypast.

In late July 1947 the ADP incorporating the changes requested by the mock-up review commission was submitted to GK NII VVS for review. After that the Soviet Air Force Commander-in-Chief endorsed both the project itself and the protocol of the mock-up review commission.

According to the ADP the '77' (Tu-10) was an interim type to be operated by the Air Force until the all-new Tu-14 jet bomber became fully operational. In the opinion of its creators, the lack of jet bombers in the Soviet Air Force's inventory turned the development of such a lead-in aircraft based on a well-mastered type into a task of prime importance.

The Tu-10 shared the general layout of the original Tu-2, with shoulder-mounted unswept wings and twin tails. The major changes included the housing of turbojet engines in nacelles adhering directly to the wing undersurface and the switch from a tail-wheel landing gear to a tricycle undercarriage. The nose gear unit retracted aft, the main units forward and featured single oleos (instead of the Tu-2's twin oleos) with the wheels outboard of them; during retraction the wheels turned through 90° to lie flat under the engines' extension jetpipes. The area-ruled nacelles had the greatest cross-section area ahead of the wing leading edge; they tapered to minimum cross-section at the point where the wing thickness was at its greatest. This design, which was colloquially known at the Tupolev OKB as *golo**vas**tik* (tadpole), reduced the drag generated by the nacelles and improved the aircraft's lift/drag ratio. This was confirmed by scale model tests in TsAGI's T-102 wind tunnel in 1948; at a speed of 50 m/sec (164 ft/sec, or 112 mph) and a zero angle of attack the maximum L/D ratio reached 16.5 – not bad at all.



A later three-view drawing of the '77' lead-in jet bomber

It should be noted that this engine nacelle and main landing gear design later found use not only on the aircraft of the Tu-14 family but on the rival Ilyushin IL-28 bomber as well.

In designing the '77' the engineers strove to retain maximum commonality with the production Tu-2. The wing planform and its basic structure remained unaltered. So did the cockpit section, the lower portions of the centre and rear fuselage incorporating the bomb bay and the ventral machine-gun installation, the upper rear fuselage incorporating the dorsal machine-gun installation and the tail unit. The principal changes were as follows:

- the ASh-82FN radial engines driving four-bladed propellers were replaced by Rolls-Royce Nene I turbojets in new nacelles and the wing/nacelle joints were redesigned accordingly;

- wing dihedral was reduced from 6° to 3°;

- the fuselage was redesigned, with a roomier navigator/bomb-aimer's station ahead of the pilot in an extended and reshaped nose; the rear fuselage was stretched by 400 mm (1 ft 3¾ in) and its cross-section height was increased by 300 mm ($11\frac{13}{16}$ in);

- a new tricycle landing gear was provided;

- new main landing gear attachment trusses were installed;

- additional fuel tanks were installed to increase total fuel capacity and the tanks' design was changed;

- the control system was altered by installing two electrically actuated elevator trim tabs;

- the wings (notably the centre section) and the tail unit structure were reinforced;

- the defensive armament was altered.

On the other hand, the OKB tried to incorporate new features and systems developed for the '72' and '73' bomber projects into the design of the '77'.

The ADP materials did not stress the aircraft's role as a tactical bomber; the aircraft was regarded as a development aircraft or, at best, as an interim type facilitating the transition to jet aircraft for flight and ground crews, should it enter production. Later, however (at the State acceptance trials stage), the military started calling the '77' a short-range bomber.

The bomber had a crew of four which was accommodated in two unpressurised compartments. As was the case on the Tu-2, the forward compartment housed the pilot (aircraft captain) and the navigator/bomb-aimer. Taking note of the Air Force's incessant complaints about the cramped navigator's station of the Tu-2, the OKB redesigned the forward crew compartment completely, modelling it after the '69' (Tu-8) bomber; as a result, the navigator/bomb-aimer could now assume a normal sitting posture instead of curling up like a foetus. The aft-firing UBT machine-gun at the rear of the Tu-2's cockpit canopy was deleted. A single forward-firing Nudelman/Suranov NS-23 cannon was installed on the starboard side of the nose, replacing the Tu-2's wing-mounted ShVAK cannons. The aft crew compartment housed the dorsal gunner/radio operator and the ventral gunner; the layout was identical to that of the Tu-2 but the increased fuselage height afforded the gunners more comfortable working conditions.

The offensive armament of the '77' (Tu-10) differed, depending on the original aircraft from which the jet bomber was converted. Possible options are detailed in the table below.

Bomb-aiming was to be performed by means of an OPB-4S optical bombsight (a Soviet copy of the US-built Norden sight) linked to the autopilot. The latter feature enabled the navigator/bomb-aimer to control the aircraft during the target run, increasing approach and bombing accuracy.

The offensive armament options of the Tu-10 ('77')

a) aircraft converted from Tu-2Ss built by the Kazan' aircraft factory No.22

Calibre, kg (lb)	Quantity internally	externally	Total weight, kg (lb)
1,000 (2,205)	1	2	3,000 (6,610)
500 (1,102)	2	2	2,000 (4,410)
250 (551)	4	2	1,500 (3,300)
100 (220)	9	-	900 (1,980)

b) aircraft converted from Tu-2Ns and Tu-2s built by the Omsk aircraft factory No.166 and the Irkutsk aircraft factory No.39

Calibre, kg (lb)	Quantity internally	externally	Total weight, kg (lb)
1,500 (3,300)	1	1	3,000 (6,610)
1,000 (2,205)	1	2	3,000 (6,610)
500 (1,102)	2	4	3,000 (6,610)
250 (551)	4	4	2,000 (4,410)
100 (220)	9	-	900 (1,980)

The defensive armament was initially to comprise two UBT-12.7 machine-guns – one on a production VUB-68 mount (*__verkh__nyaya oosta__nov__ka bombardi__rov__shchika* – dorsal [gun] mount for bombers) and one on an LU-68 ventral mount (*__lyoo__kovaya oosta__nov__ka* – lit. 'hatch mount') with 250 and 300 rounds respectively – and the abovementioned forward-firing NS-23 cannon with 80 rounds which was fired by the captain. At a later stage the dorsal and ventral mounts could be replaced with remote-controlled powered barbettes mounting single 23-mm cannons.

The bomber's armour offered the crew protection against 20-mm armour-piercing cannon shells. In designing the armour plating the OKB took account of the bomber's higher speed as compared to the propeller-driven precursor, which would make it harder for pursuing fighters to catch up with it. Protection against anti-aircraft artillery shell splinters would be afforded by 8-mm (0.31-in) duralumin slabs forming part of the load-bearing airframe structure.

According to the ADP the fuel was to be carried in 20 bag-type (bladder) tanks in the fuselage and wings holding a total of 6,254 litres (1,375 Imp gal). On the real thing (the Tu-12 prototypes), however, some of the tanks were integral tanks.

Additionally, production Tu-10s were expected to feature a Ton-2 radar warning receiver alerting of an impending fighter attack from behind, an SCh-3 IFF transponder (SCh = *svoy/choo__zhoy__* – friend/foe), an ARK-4 or ARK-5 automatic direction finder, an RV-2 radio altimeter, a marker beacon receiver and a new AP-5 electric autopilot. The electrical system was to feature DC generators rated at 6 to 9 kilowatts and some lighting equipment items from the Tu-4 (Soviet Boeing B-29 copy); the obsolescent AFA-IM camera would be replaced by an AFA-B.

As already mentioned, the Tu-10 featured a tricycle landing gear patterned on that of the projected '72' and '73' bombers. The aft-retracting nose unit had a single 720 x 310 mm (28.34 x 12.2 in) wheel and was equipped with a hydraulic shimmy damper similar to the one fitted to the North American B-25 Mitchell bomber. The forward-retracting main units had single 1,150 x 355 mm (45.27 x 13.97 in) wheels with high-pressure tyres permitting a maximum take-off weight of 22 tons (48,500 lb). A tailwheel (borrowed directly from the Tu-2) was also envisaged to protect the rear fuselage in the event of overrotation or a tail-down landing. The landing gear was operated by a separate hydraulic system, with pneumatic extension in an emergency.

Available engine thrust for the '77' (Tu-10 2 Nene-1) at N_1 = 12,000 rpm

Altitude, m (ft)	Speed, km/h (mph)				
	0	400 (248)	600 (372)	800 (496)	1,000 (620)
	Thrust (each engine), kgp (lbst)				
Sea level	2,000 (4,410)	1,820 (4,010)	1,760 (3,880)	1,740 (3,830)	1,775 (3,910)
4,000 (13,120)	1,500 (3,300)	1,360 (3,000)	1,330 (2,930)	1,330 (2,930)	1,380 (3,040)
8,000 (26,250)	1,020 (2,250)	910 (2,000)	910 (2,000)	940 (2,070)	990 (2,180)

Due to the new bomber's higher speed the Tupolev OKB paid much attention to the crew rescue system. Both of the Tu-10's crew compartments featured large forward-hinged ventral escape hatches which were opened by pneumatic rams in an emergency, acting as slipstream deflectors to protect the three crewmen bailing out that way. Yes, three – the forward hatch served the navigator/bomb-aimer only. As for the pilot, the Tu-10 was to feature an ejection seat – for the first time in the OKB's practice; the cockpit canopy roof was to be jettisoned before ejection.

Being the most important new feature, the powerplant received the greatest attention. The table at the top of this page illustrates how the thrust of the RR Nene I (or its licence-built version, the RD-45) at the constant engine speed of 12,000 rpm and the Tu-10's design speed depended on the flight altitude.

As already noted, the engine nacelles and their attachment fittings had to be designed from scratch. To minimise the fire hazard the engines were carefully isolated from the airframe structure and equipped with a carbon dioxide fire suppression system.

It is well known that gas turbine engines run on kerosene rather than aviation gasoline (except for a few multi-fuel military turbofans which will 'drink anything combustible'). This created new problems for aircraft designers; among other things, kerosene is less volatile than Avgas, and a leaky fuel line might cause kerosene to seep into other aircraft systems and ruin them. Hence special measures were taken when the Tu-10's fuel system was designed. First of all, bladder tanks were selected over integral tanks, being less susceptible to vibration (although the designers made an allowance that the first Tu-10s may be temporarily equipped with a number of integral tanks). Secondly, all joints in the fuel system were carefully sealed against leaks.

Most of the 20 tanks were housed in the wings. The total capacity was 5,233 litres (1,151.26 Imp gal); at a specific gravity of 0.806 g/cm^3 this amounted to a fuel load of 4,218 kg (9,299 lb). There were four groups of tanks (two for each engine); for higher reliability they were connected by a cross-feed valve. The fuel was fed to the engines by electric delivery pumps. Two additional tanks holding 510 litres (112.2 Imp gal)/411 kg (906 lb) each were installed immediately aft of the forward crew compartment; these were balancing tanks connected to their respective engines. The pilot used the fuel from these tanks as required to maintain CG position, switching on the fuel transfer pumps inside these tanks manually. Total fuel capacity was thus 6,253 litres (1,375.66 Imp gal) or 5,030 kg (11,090 lb).

The tables below illustrate the specifications of the '77' bomber as per advanced development project.

Specifications of the '77' (Tu-10 2 Nene-1) (manufacturer's estimates)

Wing span	18.86 m (61 ft 10½ in)
Length overall	15.75 m/*16.45 m** (51 ft 8 in/*53 ft 11¾ in**)
Height on ground	4.19 m (13 ft 9 in)
Wing area, m^2 (sq ft)	48.8 (524.73)
Mean aerodynamic chord	2.855 m (9 ft 4¹³⁄₃₂ in)
Tailplane span	5.3 m (17 ft 4⅝ in)
Horizontal tail area, m^2 (sq ft)	8.72 (93.76)
Vertical tail area, m^2 (sq ft)	5.83 (62.68)
Landing gear track	6.0 m (19 ft 8¼ in)
Empty weight, kg (lb)	8,880 (19,580)
All-up weight, kg (lb):	
normal	12,700 (28,000)
maximum	15,400 (33,950) †
Fuel load, kg (lb)	2,100 (4,630)
Bomb load, kg (lb):	
normal	1,000 (2,205)
maximum	3,000 (6,610)
Maximum speed, km/h (mph):	
at sea level	780 (484)
at 6,000 m (19,685 ft)	775 (481)
Landing speed with a 9,460-kg landing weight, km/h (mph)	150 (93)
Climb time to 5,000 m (16,400 ft), minutes	5
Service ceiling, m (ft)	12,000 (39,370)
Take-off run with a 15,400-kg (33,950-lb) maximum AUW, m (ft)	1,200 (3,940)
Landing run with a 9,460-kg (20,855-lb) landing weight, m (ft)	500 (1,640)

* The figures in italics are the definitive ones (the length was changed in the course of the design work)

† Including 4,800 kg (10,580 lb) of fuel

Estimated range performance of the '77' (Tu-10 2 Nene-1) with various ordnance loads

TOW, kg (lb)	Fuel load, kg (lb)	Bomb load, kg (lb)	Flight altitude, m (ft)	Speed, km/h (mph)	Range, km (miles)
12,700 (28,000)	2,100 (4,630)	1,000 (2,205)	6,000 (19,685)	600-620 (372-385)	650-700 (403-434)
15,400 (33,950)	4,800 (10,580)	1,000 (2,205)	6,000 (19,685)	600-620 (372-385)	1,500 (931)
15,400 (33,950)	4,800 (10,580)	3,000 (6,610)	6,000 (19,685)	600-620 (372-385)	700 (434)

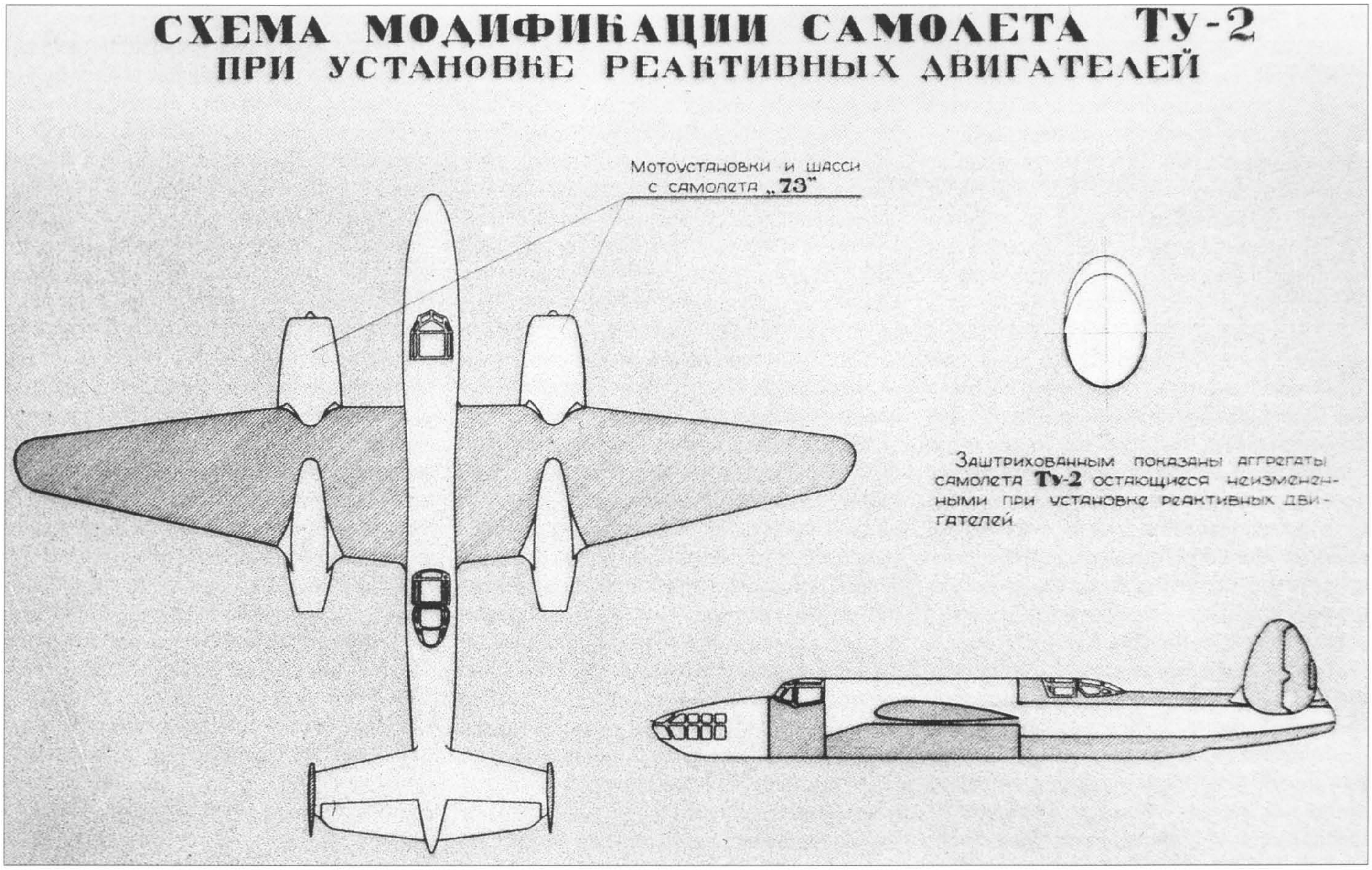


СХЕМА МОДИФИКАЦИИ САМОЛЕТА Ту-2
ПРИ УСТАНОВКЕ РЕАКТИВНЫХ ДВИГАТЕЛЕЙ
Мотоустановки и шасси с самолета „73"
Заштрихованным показаны аггрегаты самолета Ту-2 остающиеся неизмененными при установке реактивных двигателей

Above: The shaded areas show the parts of the Tu-2's airframe retained in the process of conversion to the Tu-10; actually there is not much left of the original structure.
Below: This drawing illustrates the Tu-10's defensive armament and its fields of fire.

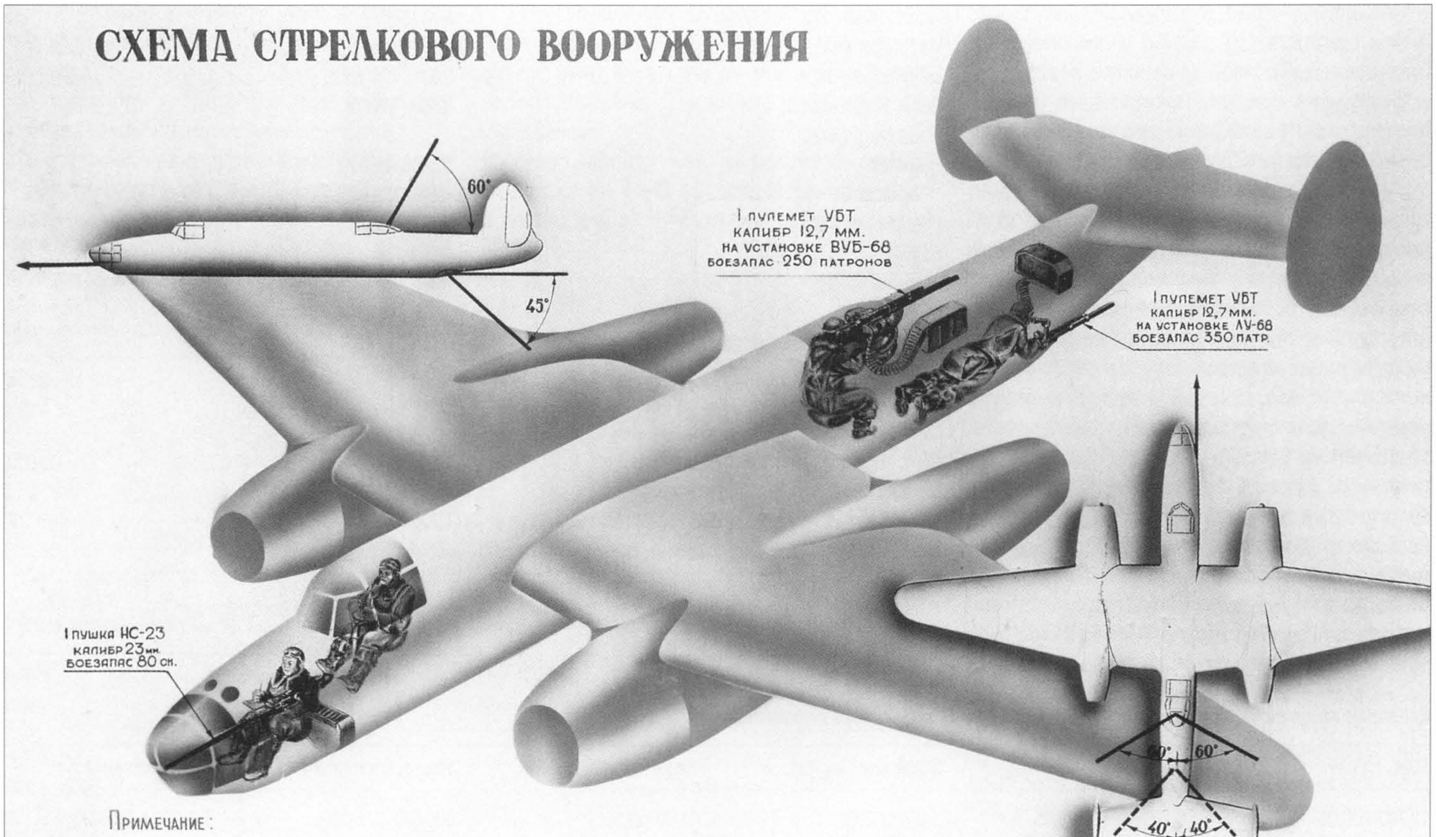
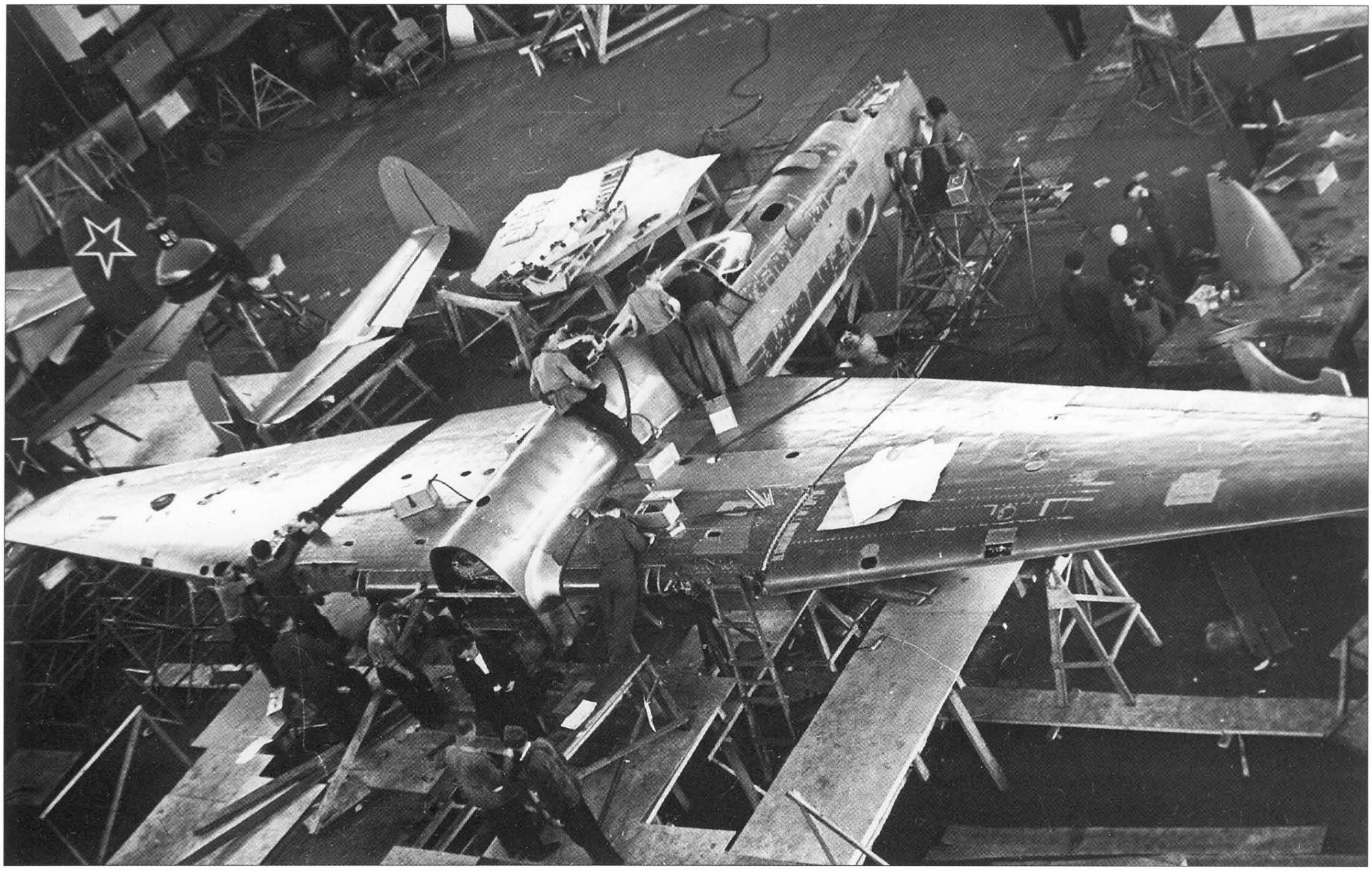
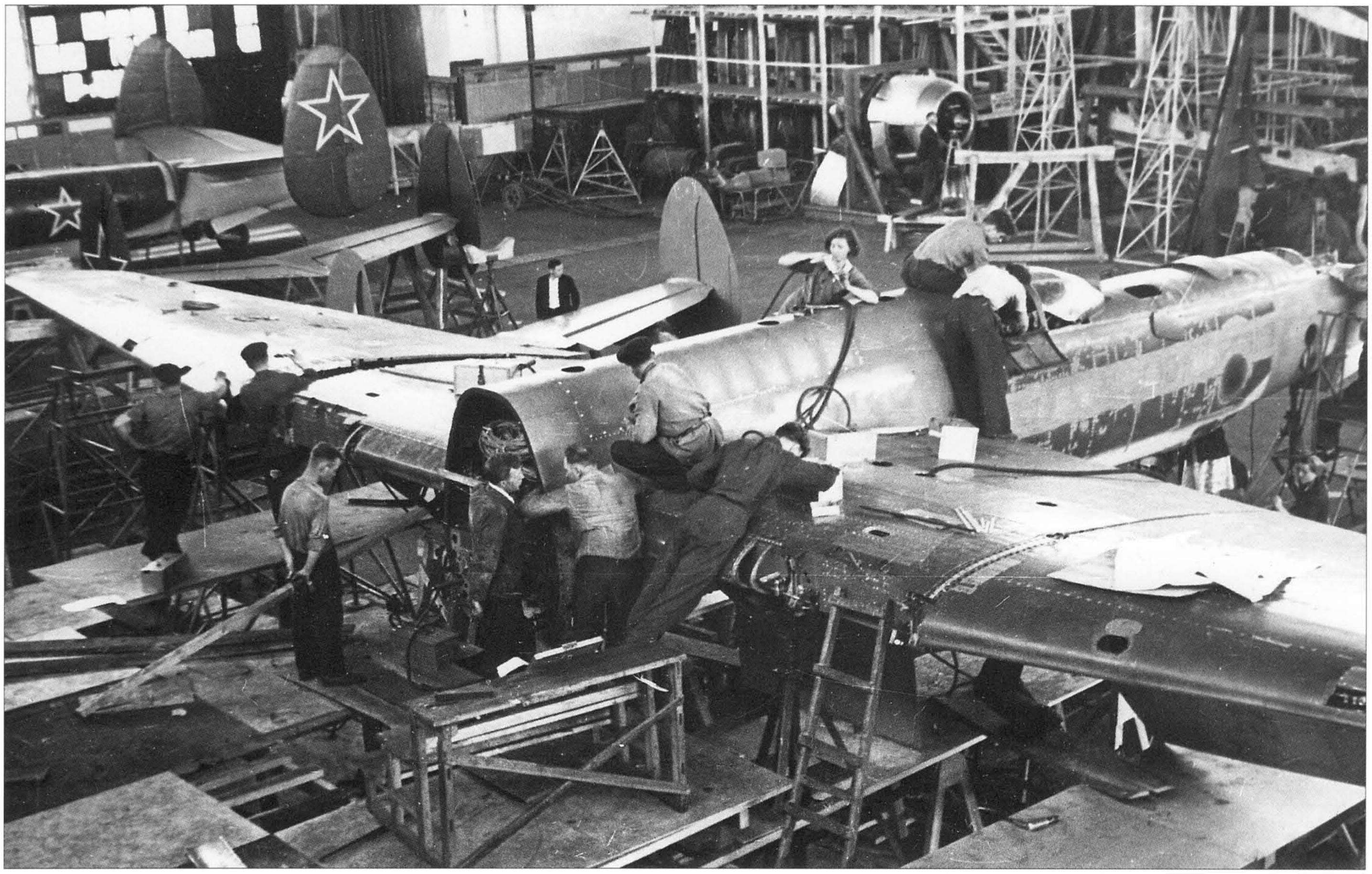
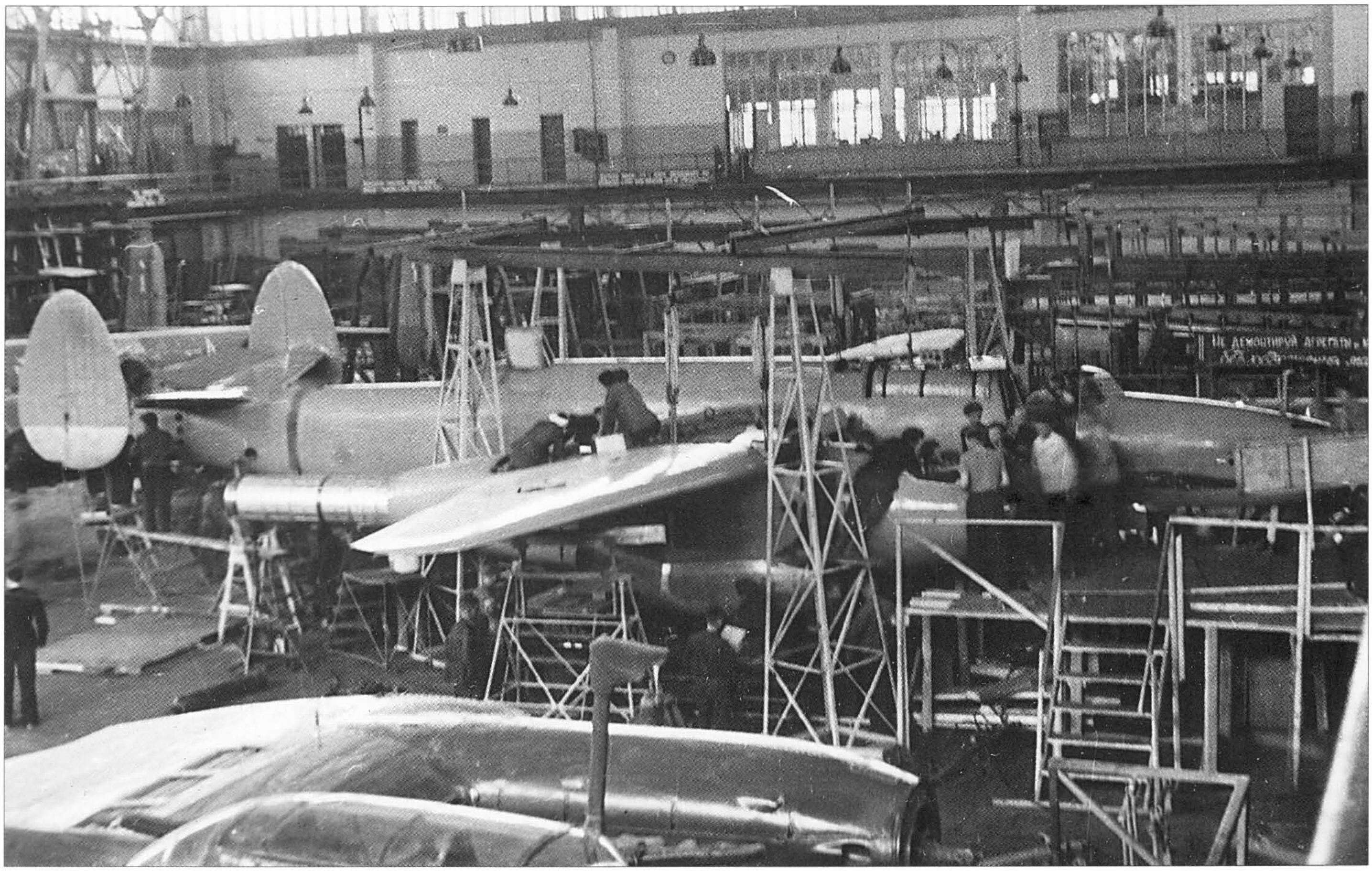


СХЕМА СТРЕЛКОВОГО ВООРУЖЕНИЯ
60°
45°
1 пулемет УБТ калибр 12,7 мм. на установке ВУБ-68 боезапас 250 патронов
1 пулемет УБТ калибр 12,7 мм. на установке ЛУ-68 боезапас 350 патр.
1 пушка НС-23 калибр 23 мм. боезапас 80 сн.
60°
60°
40°
40°
Примечание:
Предусматривается замена обоих задних установок на дистанционные установки под 1 пушку калибра 23 мм. с углами обстрела в 60° по конусу.



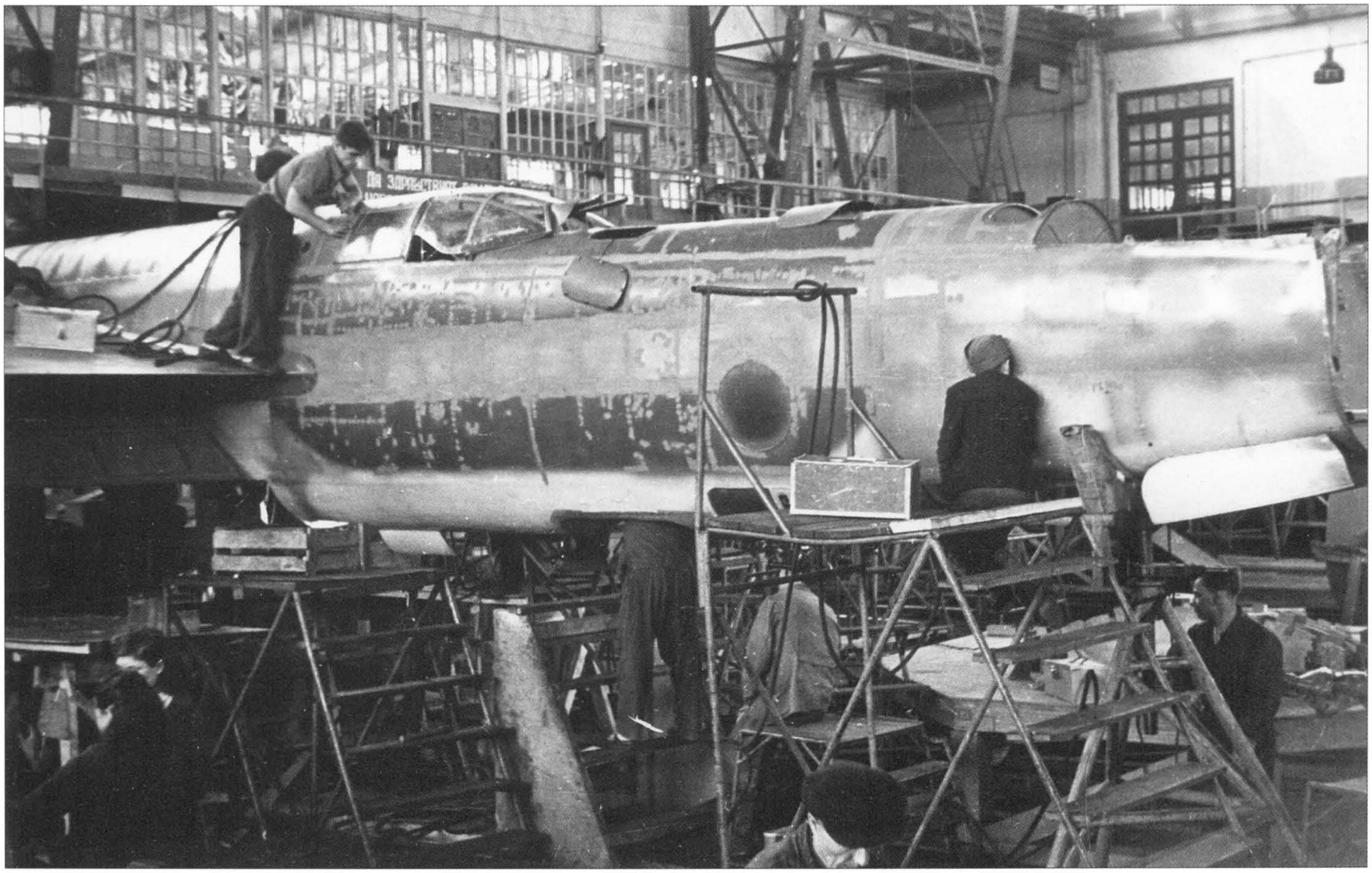
Above and below: The '77' (Tu-10) prototype at MMZ No.156 in Moscow in the process of conversion (or rather remanufacture) from a Tu-2. The unpainted areas of new structure inserted between the sections of the original Tu-2 structure are clearly visible.

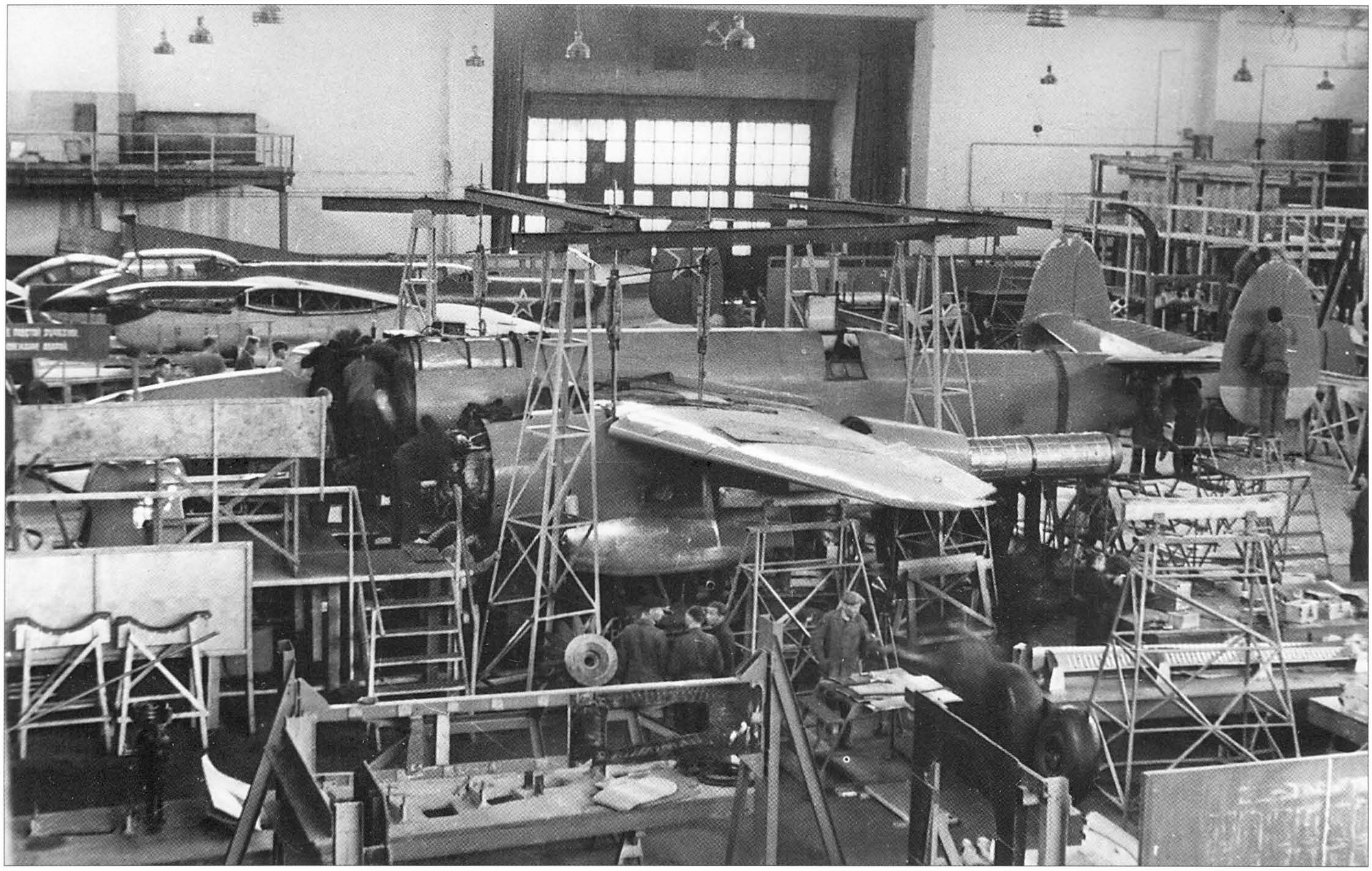




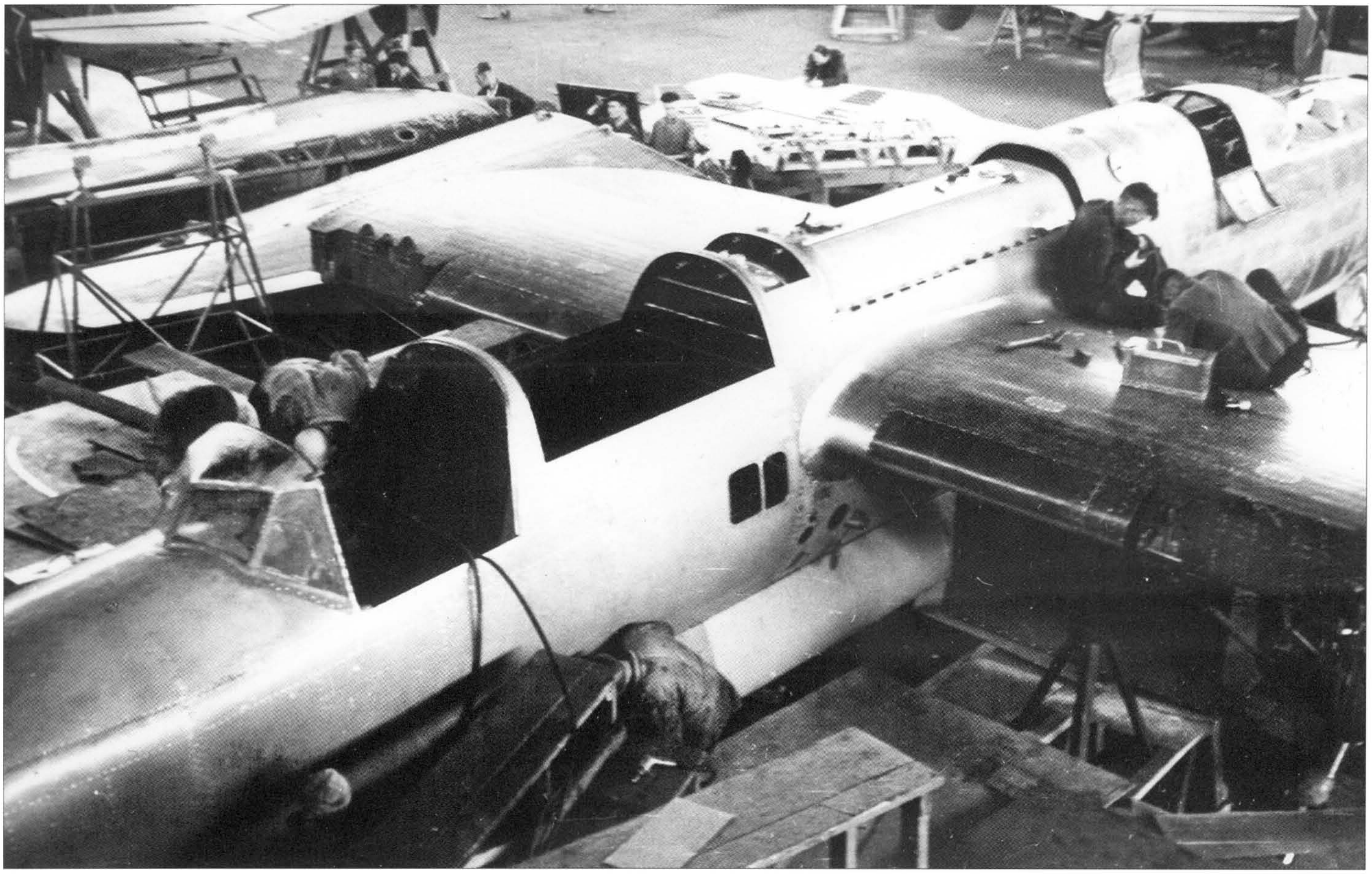
Above: The ‘77’ prototype takes shape. The aircraft in the foreground is a late variation on the Tu-2 theme with water-cooled Vee engines.

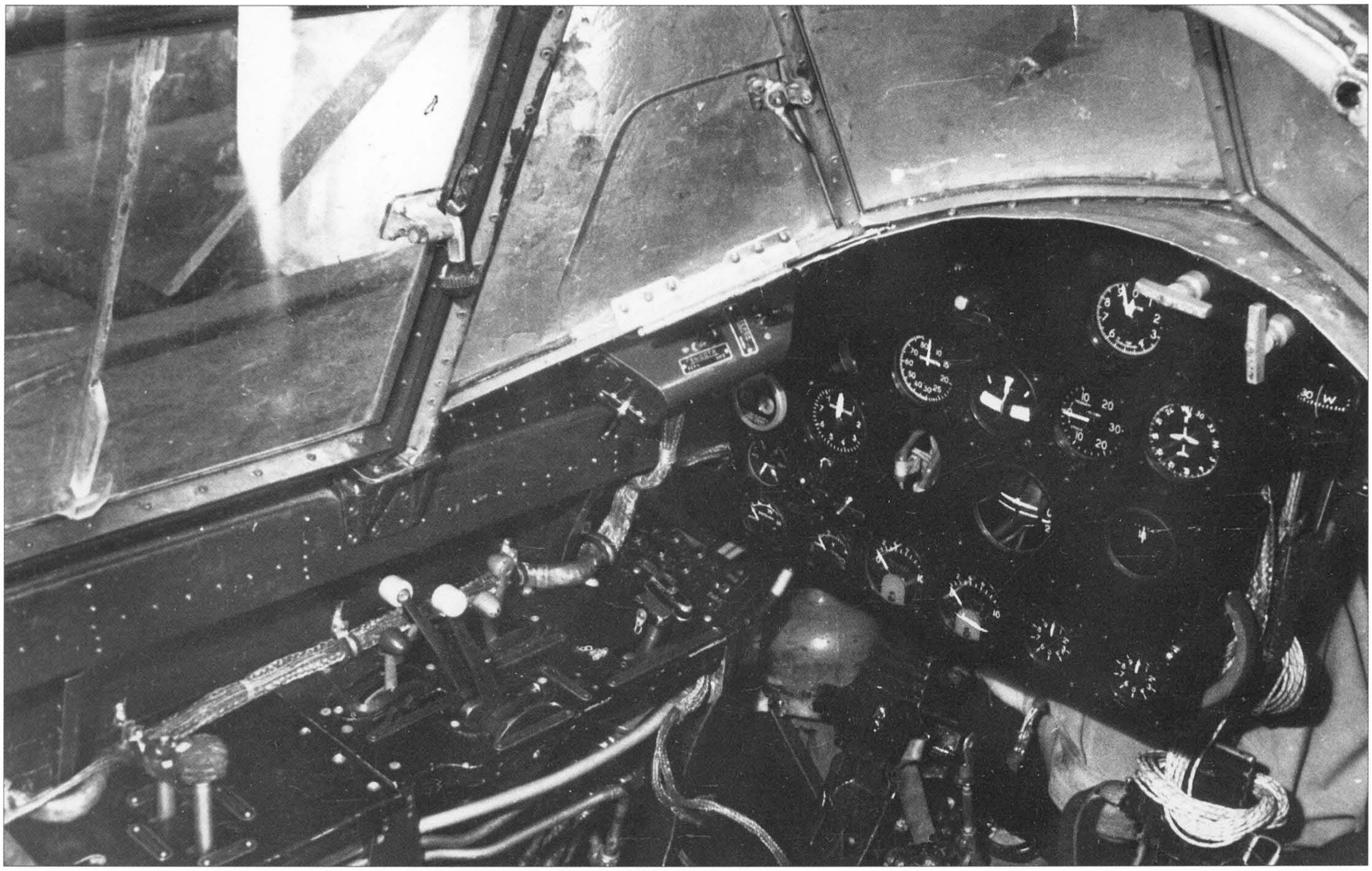
Below: Close-up of the heavily modified rear fuselage. The tailwheel well doors are still there.



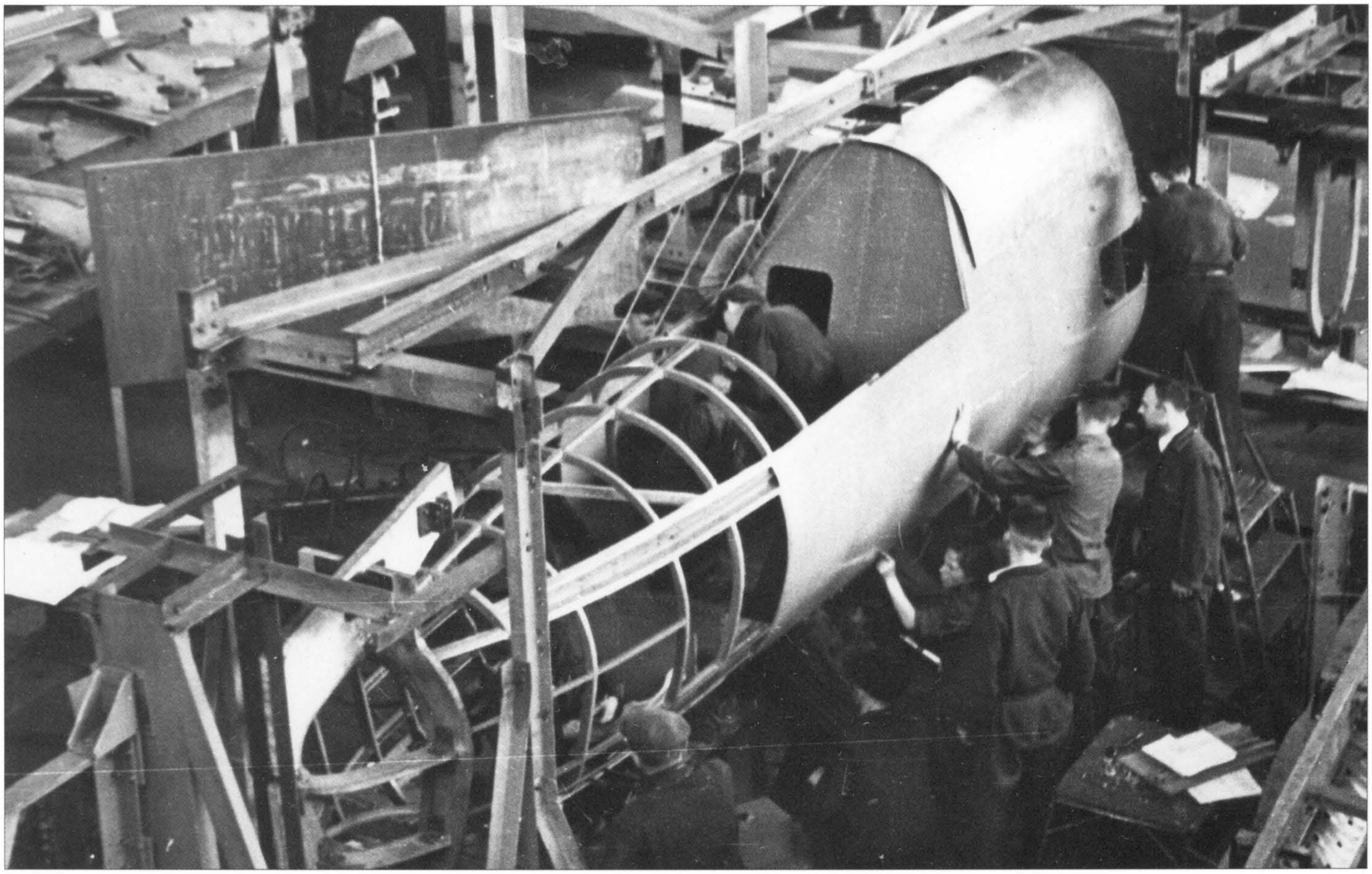


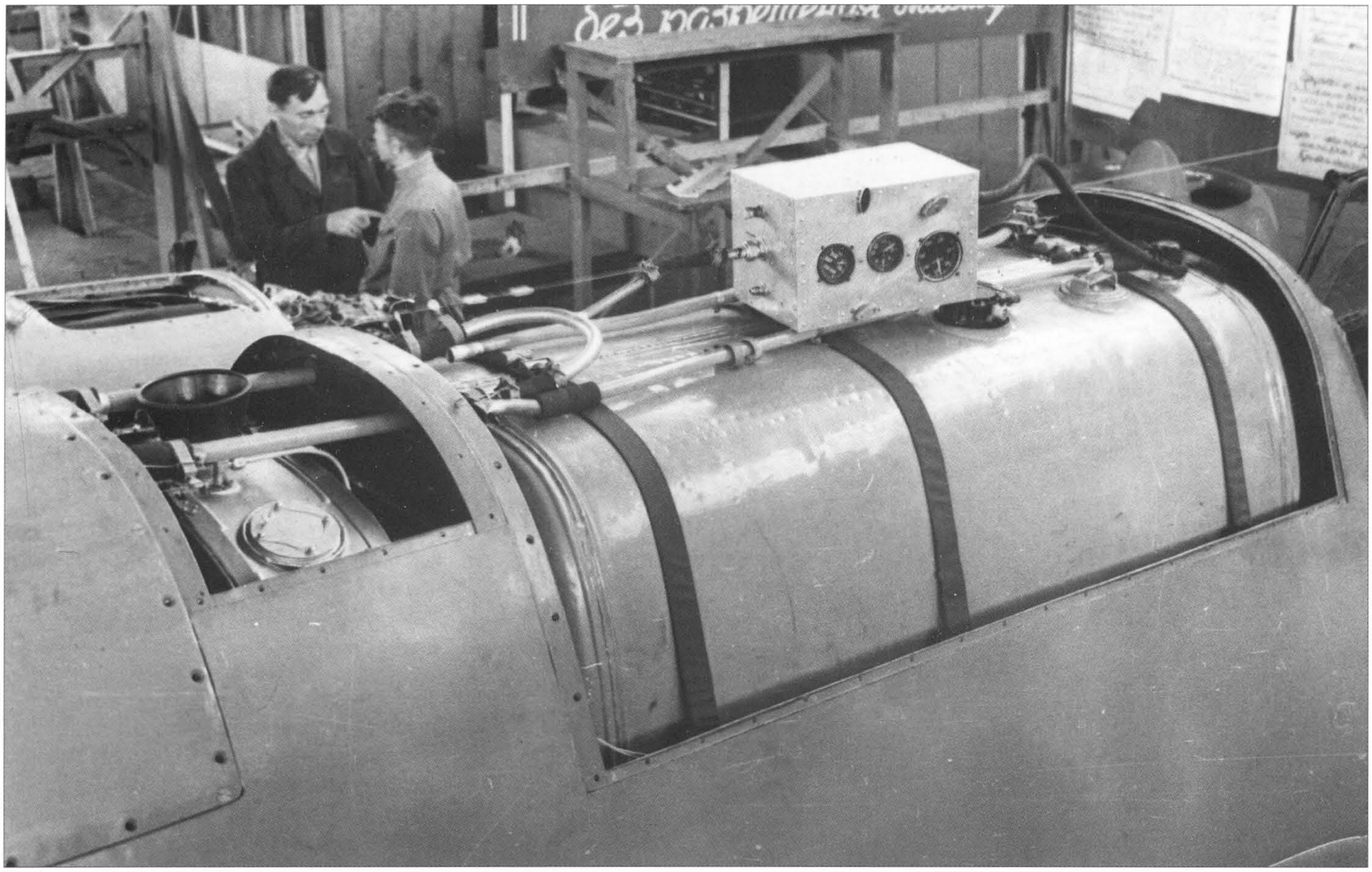
Above: Another view of the almost complete '77' amid a thicket of work platforms. Note the partially installed extension jetpipe protruding from the engine nacelle. Below: The space above the bomb bay was occupied by fuel tanks. The forward fuselage tank is not yet installed in this view.



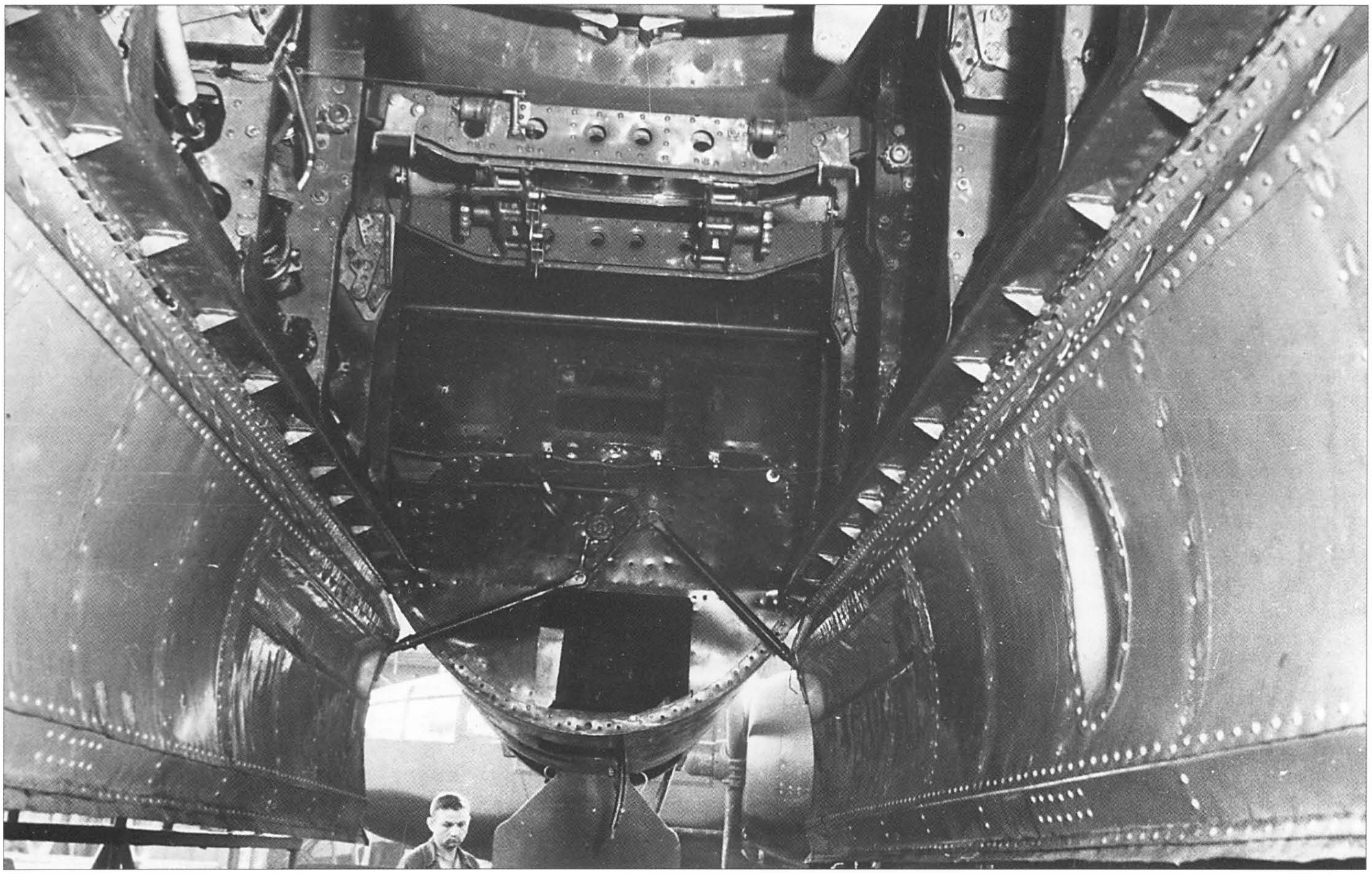


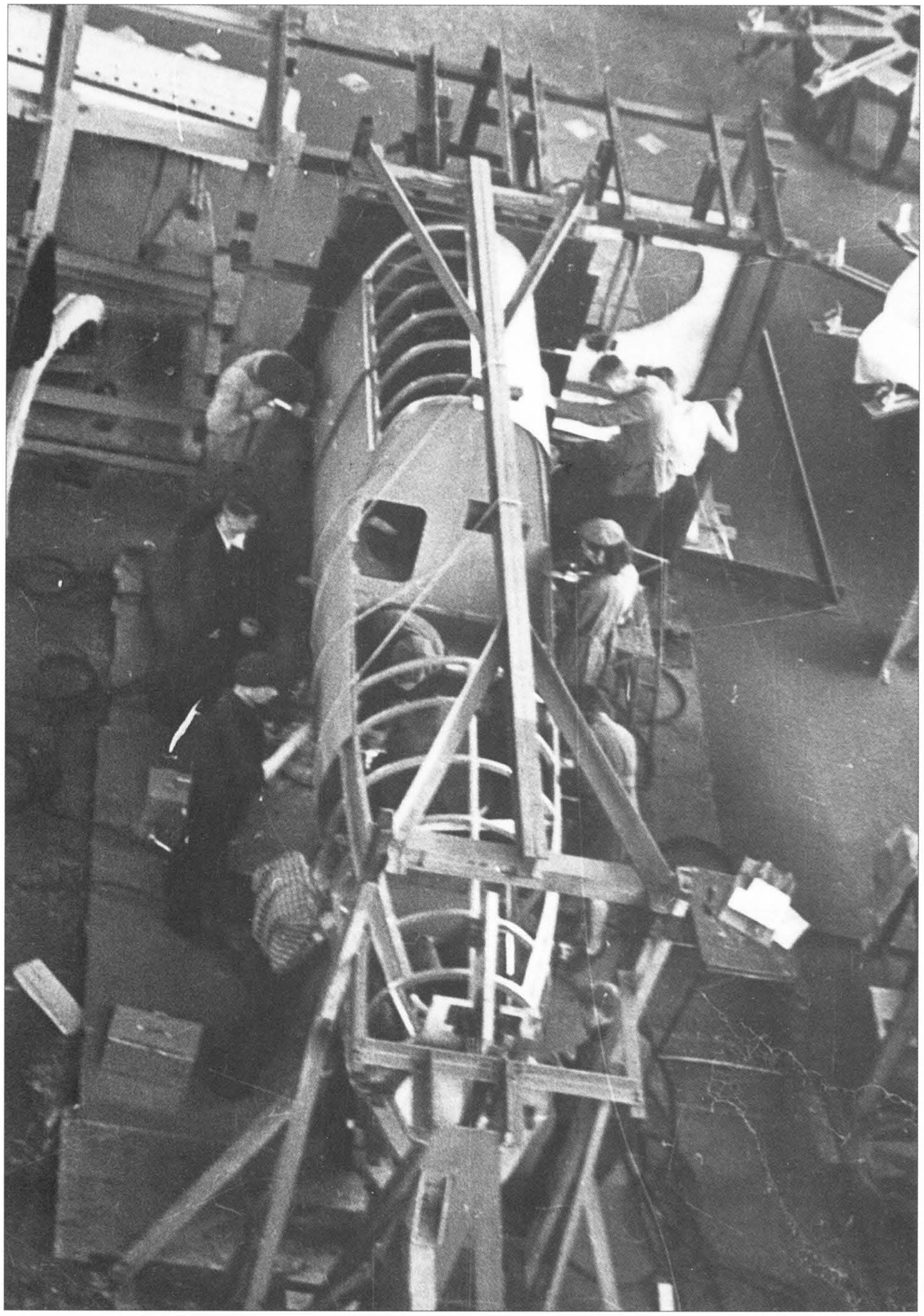
Above: The cockpit of the Tu-10. Note the two pull handles of the fire extinguishing system at the top of the instrument panel.
Below: The forward fuselage build-up area. With the skin yet to be attached, the framework of the navigator's station is clearly visible.





Above: The forward fuselage fuel tank held in place by retaining straps; the fuel filler cap is aft of it. The box on top is apparently a test instrument.
Below: The Tu-10's bomb bay, looking aft, with the door actuating shaft and linkages on the rear wall. Note the open escape hatch of the gunners' cockpit further aft.





Another view of the partially completed forward fuselage. The ejection seat guide rails in the cockpit are not yet installed.

In early July 1947 the OKB's flight and ground crews began preparing to fly and service the '77' prototype. On 26th July, a day before the maiden flight, MAP issued order No.501 assigning the test crew for the manufacturer's tests, with Aleksey D. Perelyot as project test pilot, N. A. Ghenov as engineer in charge of the tests and N. F. Mayorov as radio operator.

Earlier, on 20th July, the prototype had been trucked to the Tupolev OKB's Zhukovskiy flight test facility and reassembled, undergoing ground tests and systems checks in the course of the ensuing week. The powerplant caused the most trouble and kept everyone plenty busy, since the OKB was breaking new ground – it had next to no prior experience with jets.

The manufacturer's flight tests lasted from 26th July to 10th September 1947. On 27th July the '77' successfully performed its 18-minute first flight. The event was attended by Chief Designer Andrey N. Tupolev; when the bomber had landed safely, he quoth, 'Well, now we've seen for ourselves that it is possible to fly without airscrews!'

As late as the beginning of the manufacturer's flight tests the aircraft was still officially designated Tu-10, and this designation was actually painted on the port side of the prototype's nose. Soon, however, the designation Tu-10 was reassigned to the production prop-driven bomber known in-house as the '68' (a variant of the Tu-2 powered by 12-cylinder water-cooled Mikulin AM-39FNV-2 engines), while the '77' was redesignated Tu-12. It is by this name that the aircraft is best known.

The testing and debugging of OKB-156's jet firstling proceeded virtually round the clock; test flights were made in the daylight hours, the rest of the day being devoted to processing the results and making changes to the structure and systems. Andrey N. Tupolev kept a close eye on the progress of the tests, going to Zhukovskiy by car almost daily to receive reports on progress and modifications made. Two days after the maiden flight the bomber flew three test sorties in one day – one flight at low level and two flights to determine the field performance. On 1st and 2nd August three more flights were made in order to train for the forthcoming Tushino event. The unyielding dedication of the entire staff at OKB-156 (including the flight and ground crews, of course) bore fruit – just a week after the first flight the aircraft was cleared to participate in the flypast, having by then only ten flights on its tail... er, twin tails.

On 3rd August 1947 the well and truly historic event took place – the *new Soviet jet bomber designed by A. N. Tupolev* (as it was customary to phrase it in those days at public events and in the media – no designations, see) made its public appearance at the Aviation Day flypast. It was accompanied over Moscow-Tushino by other Tupolev development aircraft – the twin-engined '63' and '69' bombers, the Tu-70 four-engined airliner prototype and the first three production B-4 bombers (this was the designation worn originally by the Tu-4). It was a historic day for the Ilyushin OKB, too, as the IL-22 four-turbojet experimental bomber (which had made its first flight three days ahead of the '77') also participated in the flypast. Thus the objective set by the Soviet government and the Communist Party had been successfully accomplished – the Soviet Union had demonstrated for the world to see that its design bureaux were able to develop not only jet fighters but also bombers powered by two or even four turbojets. The Soviet people had every reason to be proud, and the dastardly enemies to be afraid – hopefully.

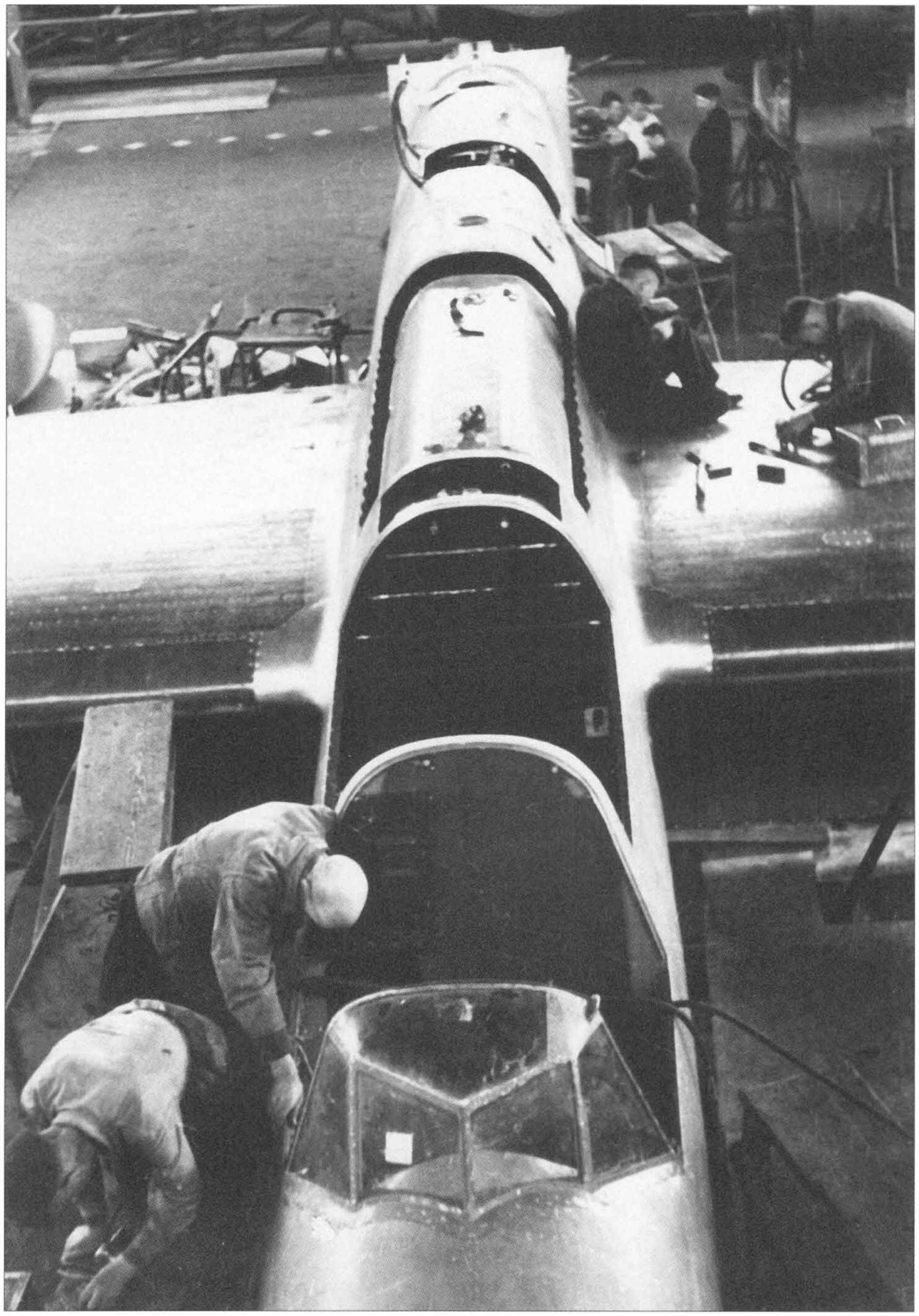
After the show the manufacturer's flight test programme resumed. On 8th August the '77' flew a sortie to determine the stability margins and control authority with different CG positions ranging from 22% to 30% MAC. After that the aircraft was in lay-up while modifications were being made; the flying resumed on 4th September when another sortie to check the stability margins was flown. The maximum speed at 10,000 m (32,810 ft) was determined on 5th September; the rate of climb at 5,000 m (16,400 ft) was checked two days later, followed on 8th September by a flight to determine the maximum speed at 10,500 m (34,450 ft) and the fuel consumption per mile. Fuel consumption in climb and descent modes was measured on the following day; also, the nose-mounted NS-23 cannon was fired for the first time in the air on that occasion. The test programme was concluded on 10th September with a sortie to check the range at 5,000 m. Well, actually two checkout flights were made afterwards – on 12th September to check the maximum speed at 10,500 m and on 22nd September to determine the maximum speed and rate of climb at 7,000 m (22,965 ft).

Generally the manufacturer's flight tests, in the course of which the '77' logged 14 hours 42 minutes in 30 flights, confirmed the OKB's performance estimates. A lot of modification and refining work had been performed at this stage, especially as regards the powerplant. Since OKB-156 had to meet tight deadlines, the aircraft which entered flight test had numerous variances and deviations from the ADP documents. Thus the main fuel tanks were integral ones, which led to constant fuel leaks (this defect was cured almost completely in the course of the tests). Many new equipment items had not been delivered in time for the first flight and had to be temporarily substituted with older models or omitted altogether. Still, in spite of all the bugs the machine completed its tests without major problems and was recommended for State acceptance trials.

On 2nd October 1947 Aleksey D. Perelyot ferried the bomber to Chkalovskaya airbase east of Moscow, the seat of GK NII VVS, to undergo State acceptance trials; by then the aircraft had been redesignated Tu-12. The trials began on 4th October, lasting until 27th February 1948; within this time frame the bomber made 66 flights totalling 56 hours 57 minutes. Due to the newness of the technology embodied in the aircraft the trials were, in effect, held jointly by GK NII VVS and OKB-156. To assist the institute the Tupolev OKB assigned three teams of specialists to the State acceptance trials programme. The design group included project engineer E. I. Serman, chief engineer (armament) D. S. Gorskiy, assistant engineer (armament) Yu. V. Lyubimov, chief engineer (equipment) M. G. Pinegin etc. The production group was headed by chief engineer (production) I. G. Karpoon. Finally, the flight test group comprised the ground staff of the OKB's flight test facility (supervised by project engineer B. N. Grozdov) and the test pilots.

A month after the commencement of the State acceptance trials Grozdov and Karpoon were reassigned to other programmes and their responsibilities passed to Serman. All the specialists on the team had by then accumulated considerable experience with the Tu-12 and were able to provide valuable assistance to the flight and ground personnel of GK NII VVS. The latter also formed a team supervised by project engineer V. A. Shoobralov. Mikhail A. Nyukhtikov was appointed the Air Force's project test pilot, with N. P. Tsvetkov as project test navigator, A. S. Ponomaryov as chief engineer (powerplant), N. P. Burmistrov as chief engineer (armament) and A. F. Tolpyshkin as chief engineer (equipment).

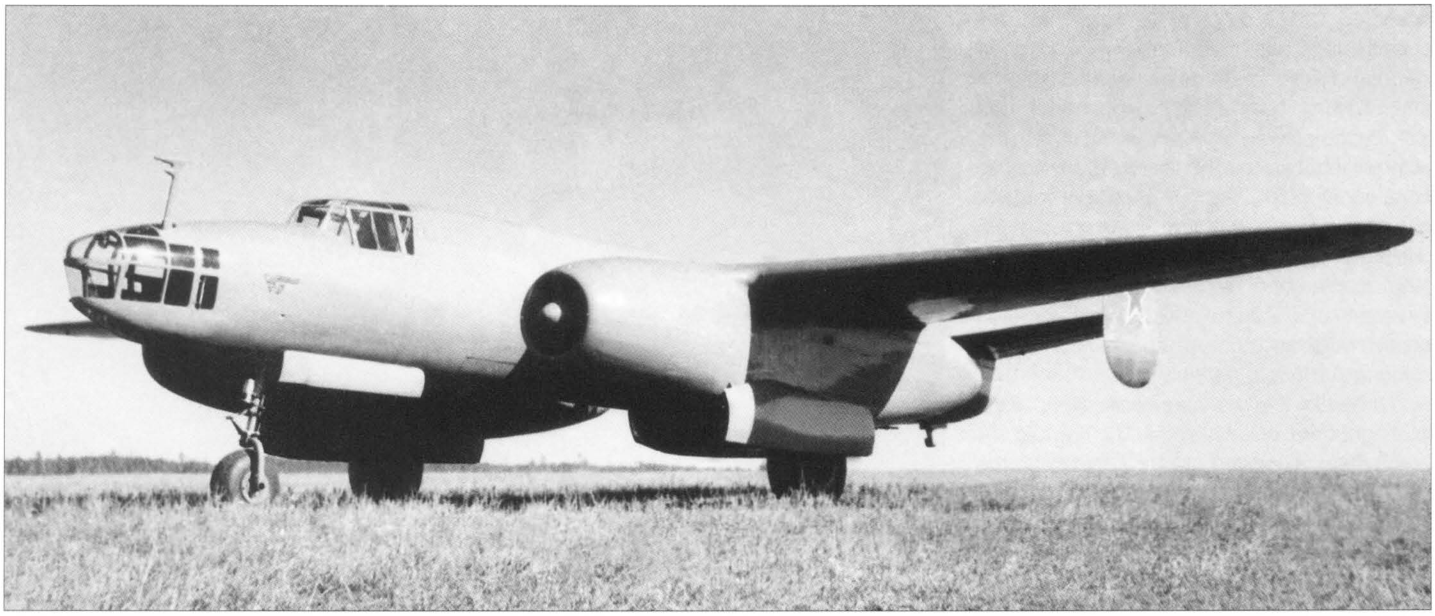
In the course of the trials the Tu-12 was flown by many Air Force test pilots and navigators, including Maj. Gen. Pyotr M. Stefanovskiy (Deputy Chief of Flight Training of GK NII VVS's Section 1), Col. V. I. Zhdanov (Deputy Chief of Flight Training of GK NII VVS's Section 4) *et al.* Afterwards the prototype was used by the institute for six months to familiarise service pilots and navigators with jet aircraft.

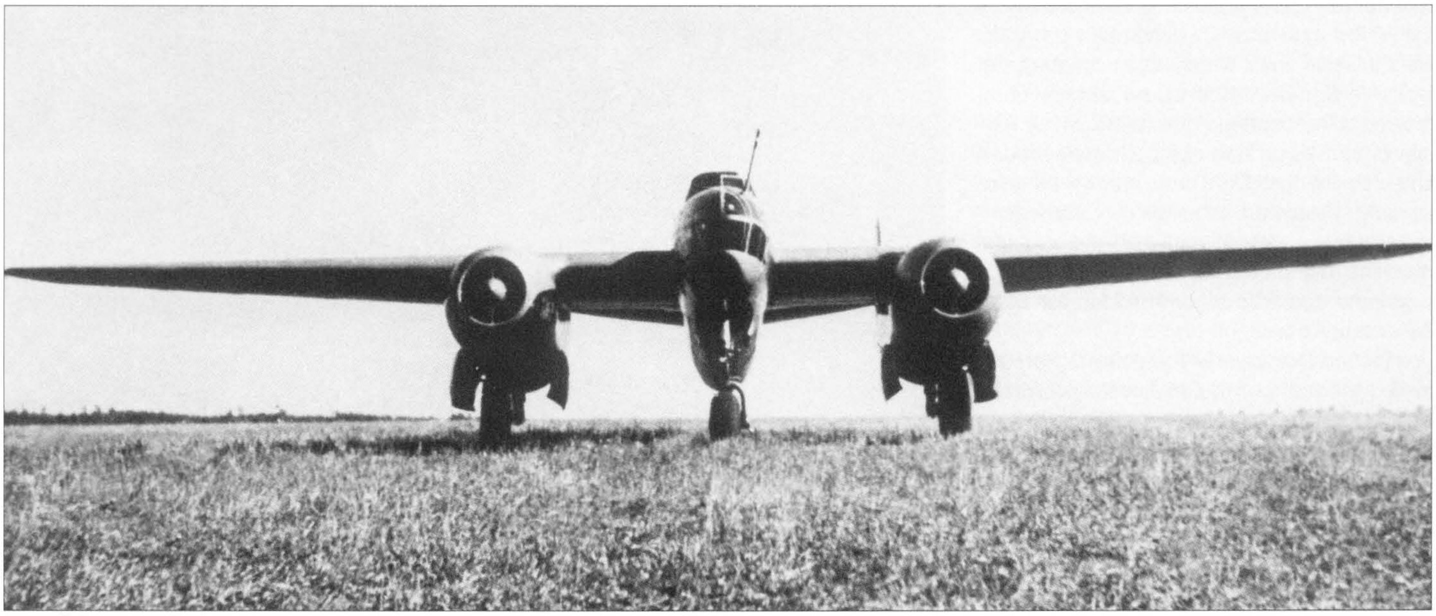


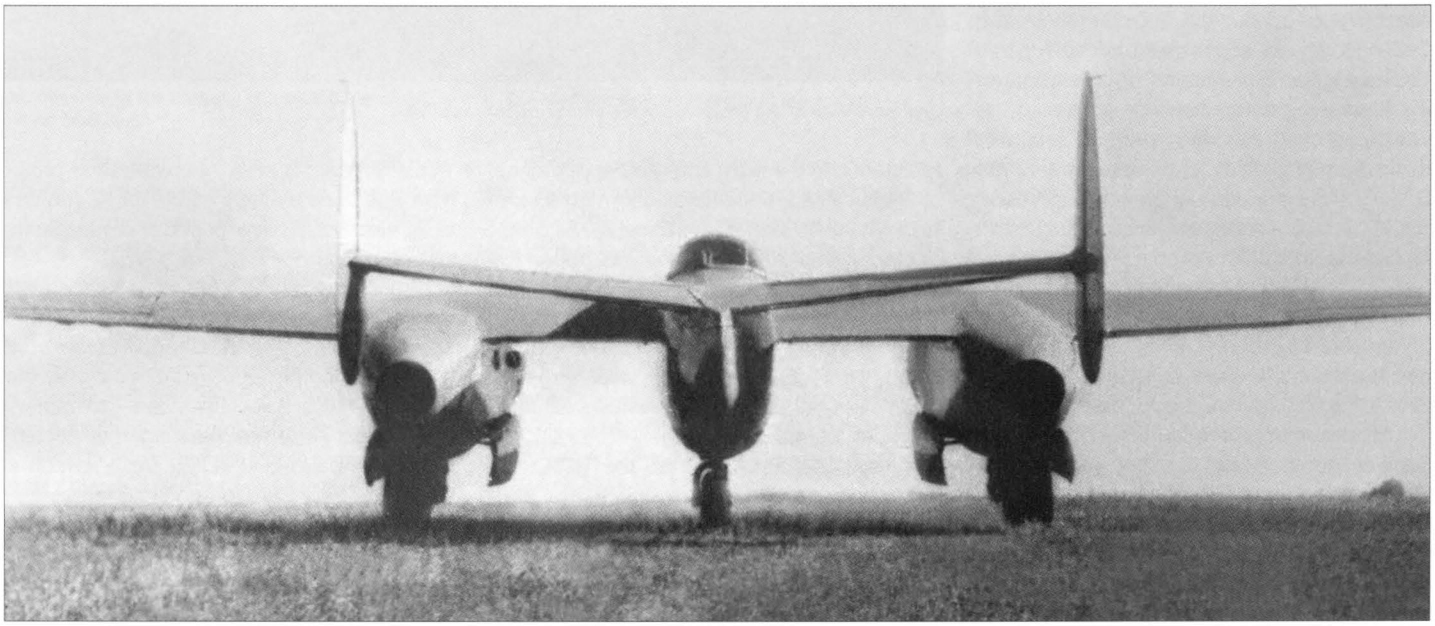
One more view of the prototype in the course of final assembly.

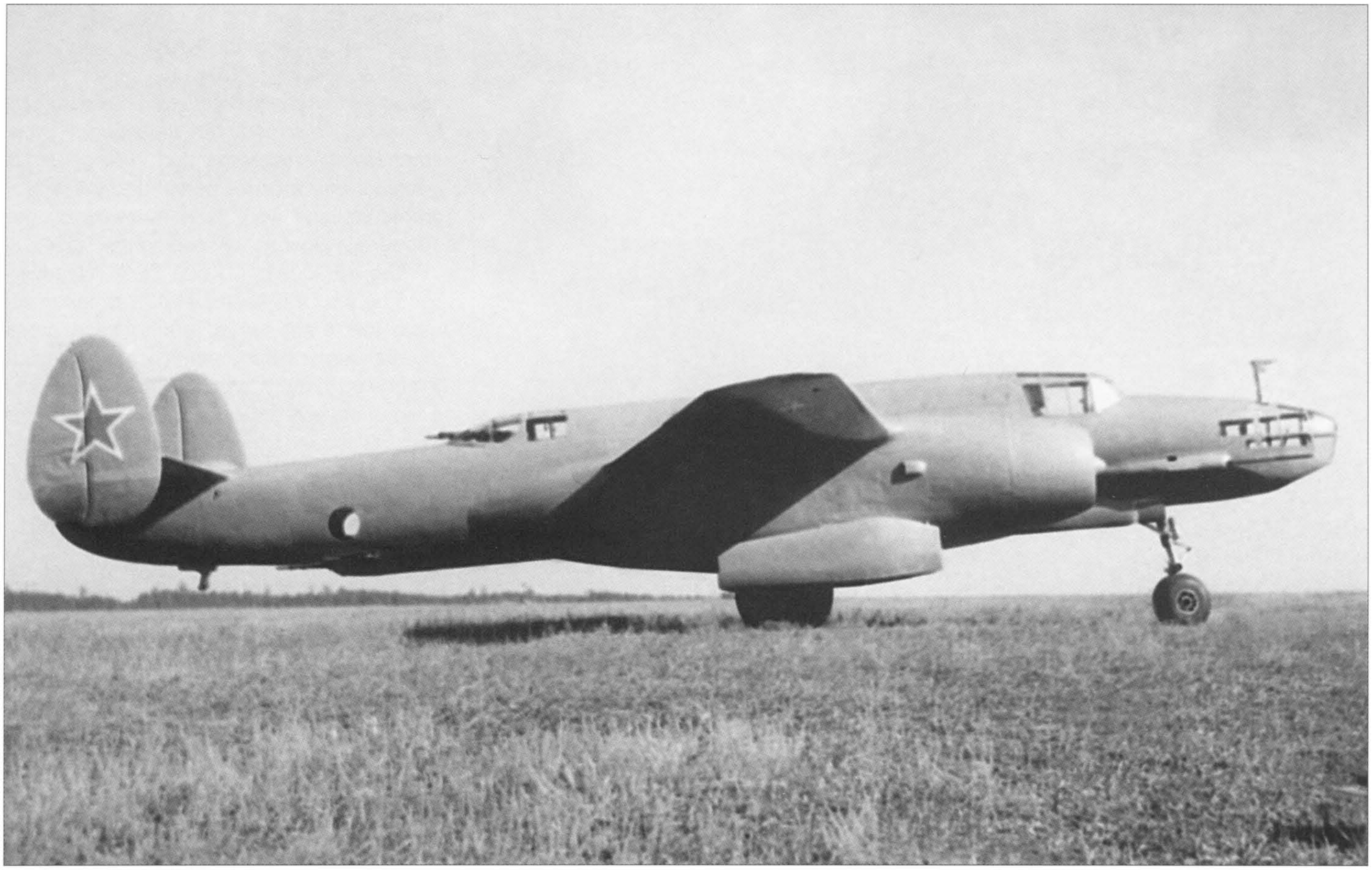
Again, during the State acceptance trials the Tu-12 made several test flights daily – with the result that any and all modification work had to be performed at night, mostly by the Tupolev OKB specialists on 'temporary deployment'. The team managed to accomplish it without disrupting the flight schedule. We will let Ye. I Baru, one of the members of the team, tell the story:

'On one occasion a canopy sidelight broke away during an extremely complicated test mission. A flight in which the chiefs of GK

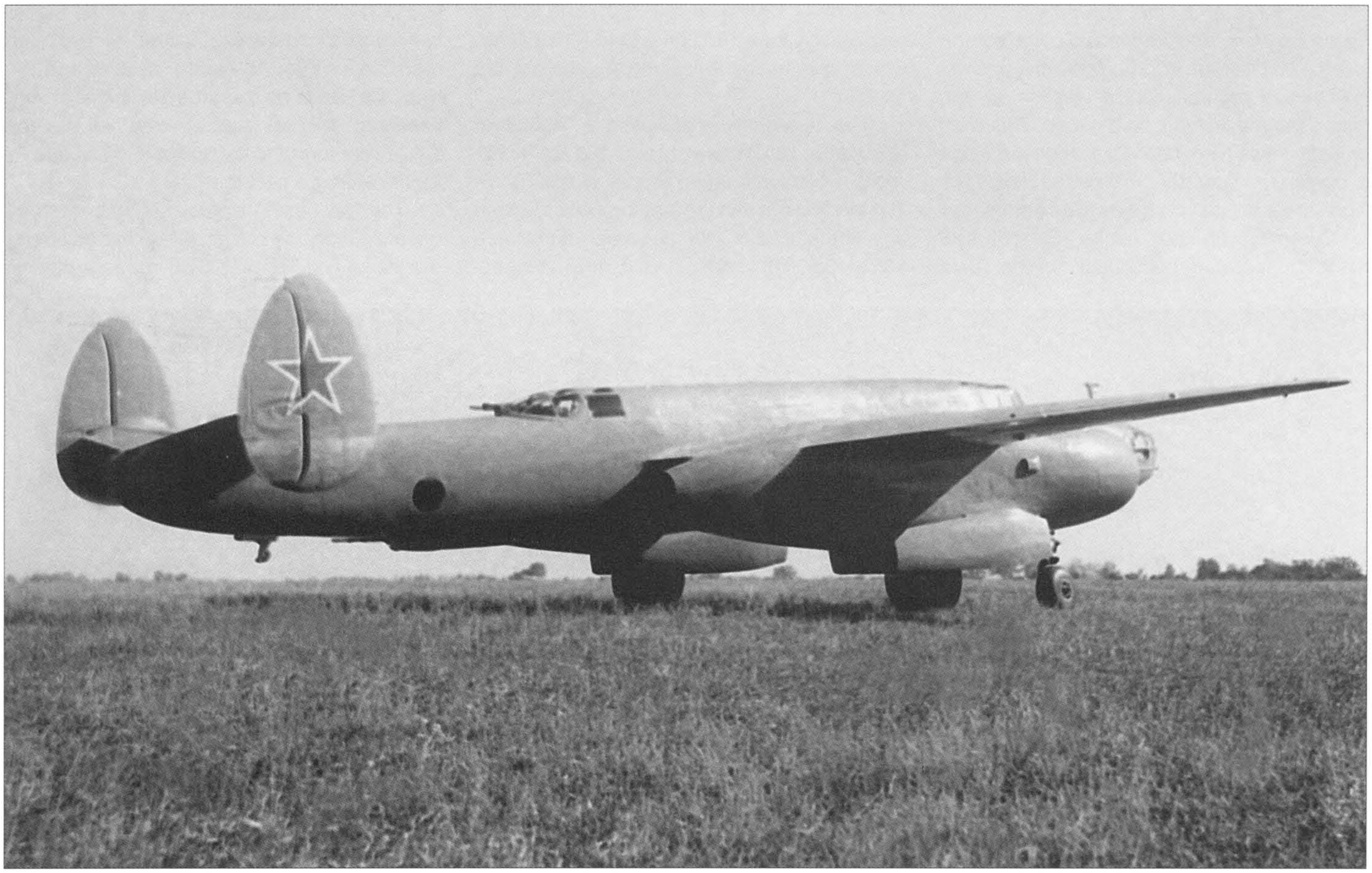








This page and opposite page: Five views of the '77' (Tu-10 2 Nene-1) during manufacturer's flight tests. Note the 'Tu-10' badge on the port side of the nose, the bullet-shaped air intake centrebodies held by cruciform struts, the exhaust-stained fins, the nose gear design featuring a half-fork and the retractable tail bumper.



Above: A rare shot of the '77' (then still officially known as the Tu-10) making a demonstration flight at the 1947 Tushino air fest.

NII VVS were to participate was scheduled for the morning after. This is where the team spirit of the group responsible for the maintenance of the hardware proved itself – the men worked like clockwork. By midnight the plant (MMZ No.156 – *Auth.*) *had delivered a new glazing panel and the installation job began. The outside temperature was about –28°C* [–18°F]. *The aircraft was standing in the open all the while. We had to install the new glazing panel literally with our bare hands. The frost was so cruel that no-one could work for longer than a minute at a time. Every man on site joined the work; one man would come up and insert a bolt into the appropriate hole, another man would promptly put a washer on and thread the nut with his bare hands. This went on until it was time for the experienced fitters to tighten the nuts. By the time the next day's flights began the aircraft was fixed and ready.'*

Summing up the results, GK NII VVS noted the following peculiarities of the Tu-12 as compared to the production Tu-2S. The turbojet engines gave a significant increase in speed amounting to nearly 250 km/h (155 mph), while the service ceiling with a 14,700-kg (32,410-lb) AUW was increased by 2,100 m (6,890 ft). The time required to reach the service ceiling and 5,000 m (16,400 ft) was reduced by 5.8 minutes and 2.8 minutes respectively. On the minus side, the take-off run and the distance required to reach 25 m (80 ft) were 1,030 m (3,380 ft) and 2,380 m (7,810 ft) respectively for a 14,700-kg AUW, or 1,260 m (4,130 ft) and 2,700 m (8,860 ft) respectively for a 15,720-kg (34,660-lb) AUW, which was nearly twice the figures for the Tu-2S.

The approach speed with a 10,000-kg (22,045-lb) landing weight was 163 km/h (101 mph), which was equal to that of the Tu-2S. The landing run and the landing distance from an altitude of 25 m with the same weight were 885 m (2,900 ft) and 1,670 m (5,480 ft) respectively, ie, 385 and 230 m (1,260 and 755 ft) longer than those of the Tu-2S.

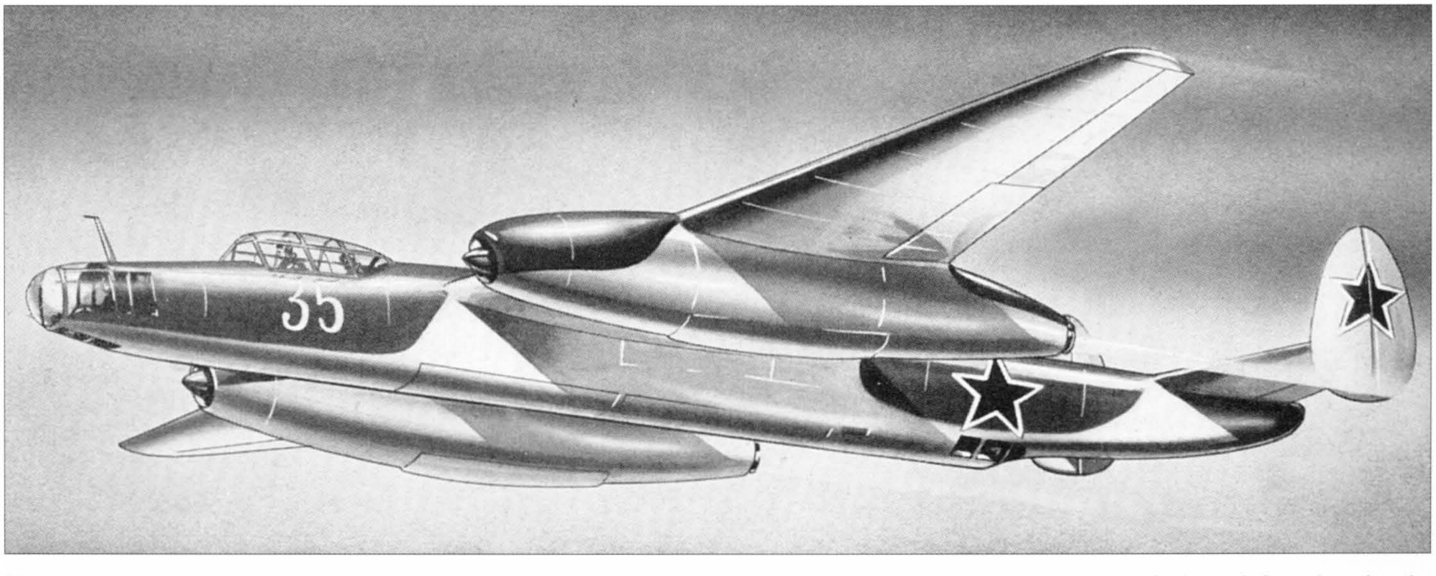
Thus the payoff for the much higher speed was a drastic deterioration of field performance. To remedy the situation the State commission recommended using JATO boosters and a brake parachute; these recommendations were later followed by the Tupolev OKB when developing the Tu-14.

The 12,700-kg (28,000-lb) AUW advertised by the OKB (with just 40% of the maximum fuel load) turned out to be a gross understatement; this amount of fuel permitted a range of no more than 530 km (330 miles) in optimum cruise at 5,000 m – which was less than half the required range. GK NII VVS proposed that the 14,700-kg AUW with 80% of the maximum fuel load be regarded as the normal figure.

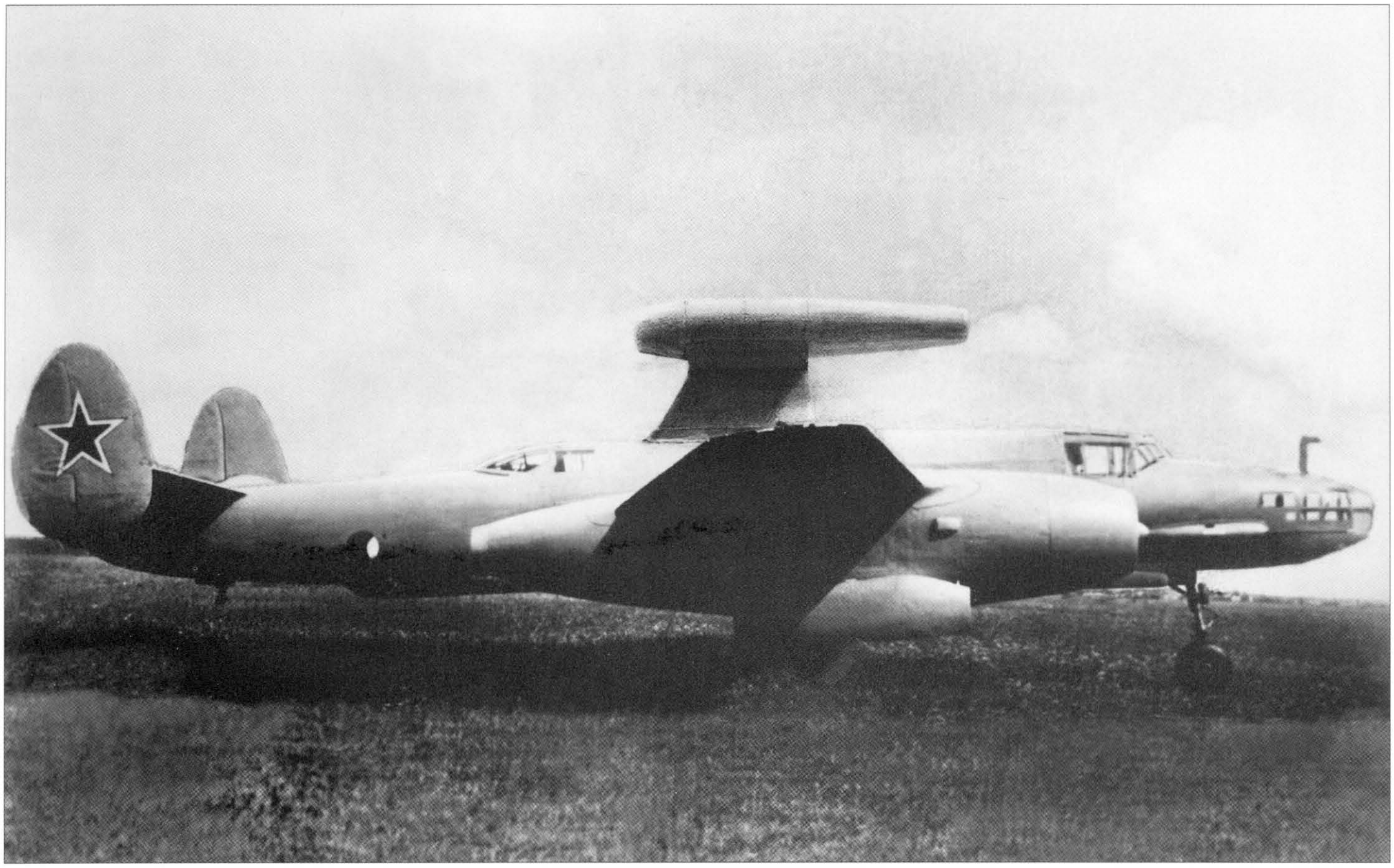
To obtain a range comparable to that of the Tu-2S the AUW had to be increased by nearly 50% (mostly by filling more fuel); the reason for this was the jet engines' much higher specific fuel consumption as compared to piston engines.

Like the Tu-2S, the Tu-12 prototype had good longitudinal stability in all flight modes throughout the authorised CG range, except for climb with the engines at full throttle with certain CG positions. Directional stability at full power had deteriorated because the jet blast impinged on the vertical tails. Elevator and rudder forces were higher as compared to the Tu-2S. The verdict was that the higher speeds and the new engine type necessitated modifications to the control system and the twin tails had to be discarded in favour of conventional tail surfaces. Nevertheless, the Tu-12 was found to be no more difficult to fly for the average pilot than the Tu-2S.

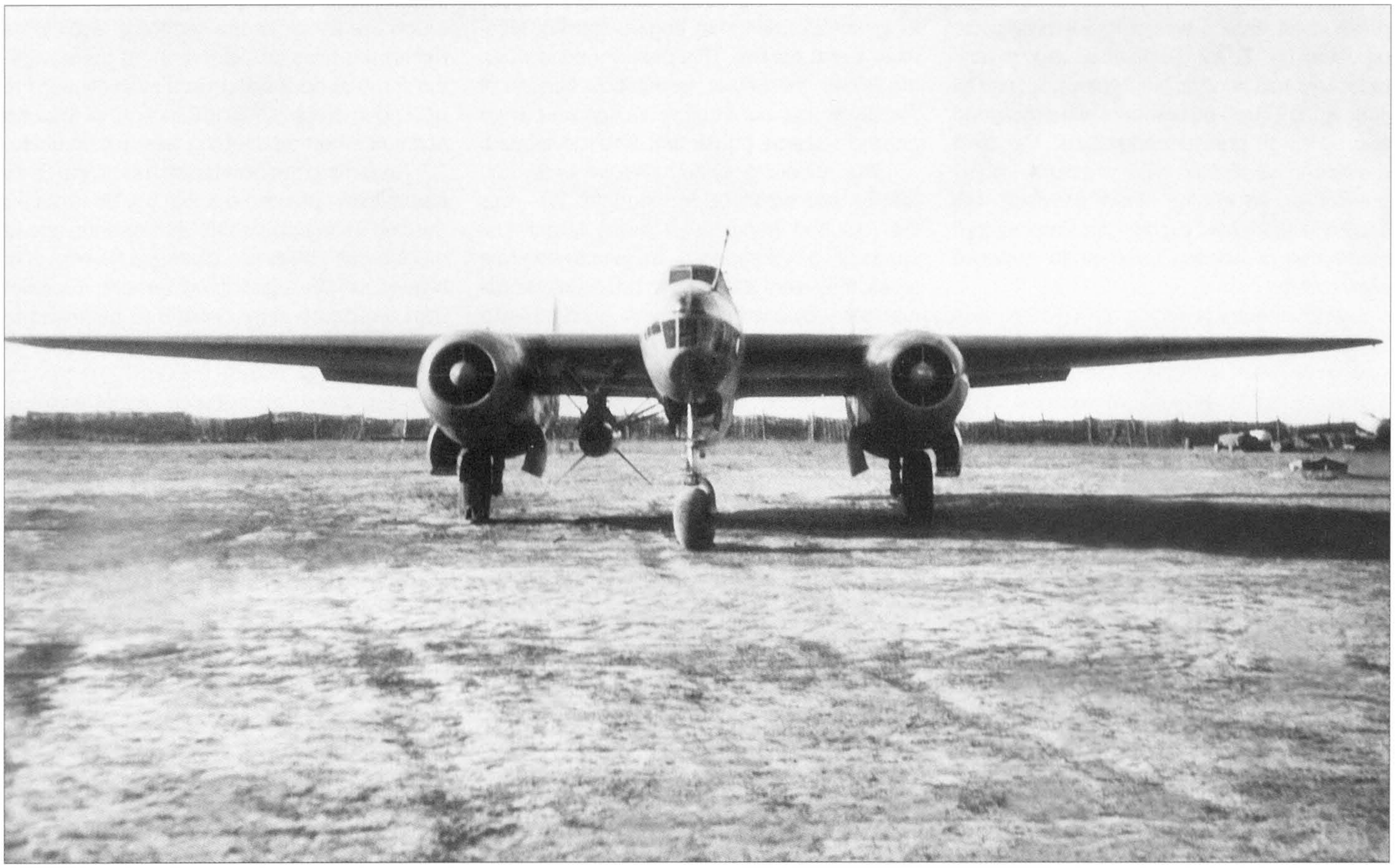
The low-set horizontal tail was deemed unsatisfactory, as the jet efflux caused strong vibration. The Tupolev OKB made a note of



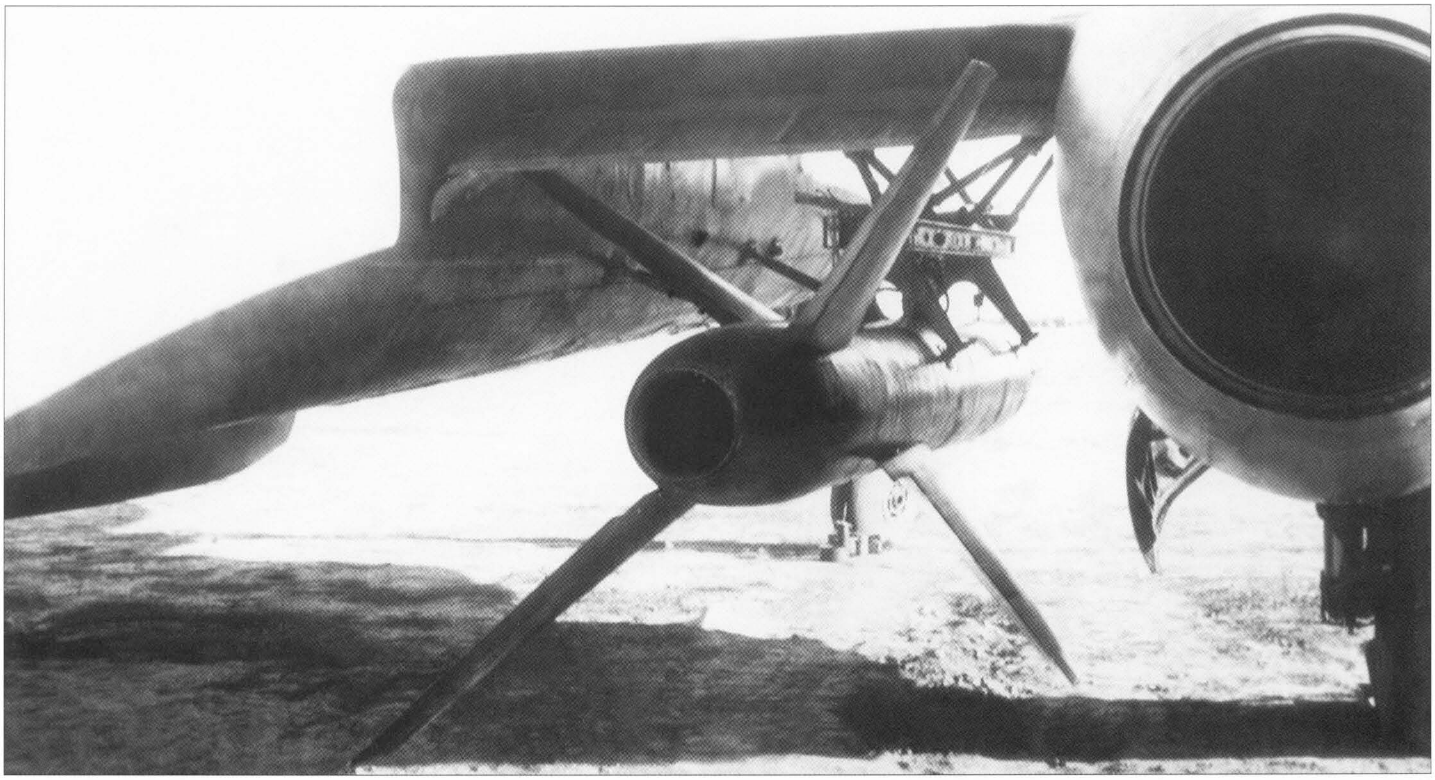
This artist's impression of the Tu-12 was published in the 1948 edition of *Jane's All the World's Aircraft*. The main inaccuracies are in the cockpit section; also, the actual aircraft was somewhat chubbier.



Above: One of the six Tu-12s was converted into the Tu-12LL testbed for the RD-550 ramjet engine designed by Mikhail M. Bondaryuk. This retouched photo shows the unusual location of the ramjet on a pylon above the fuselage. Strangely enough, the forward-firing cannon is still there.



No, this is not a missile-armed version of the Tu-12. This particular example served as a 'mother ship' for various unmanned aerial vehicles, including rockets.



Close-up of the experimental rocket under the wing of the modified Tu-12 and the beam-type rack mounted on a truss, with retaining arms to stop the rocket from swaying. Note that the two pairs of fins are staggered horizontally.

this, and all subsequent heavy jets developed by Tupolev had conventional tails with fairly high-set stabilisers.

The lack of heated and air-conditioned pressurised cabins was a major drawback, reducing the Tu-12's efficiency at high altitude. This was another lesson learned, and all subsequent Tupolev bombers were designed and built with pressurised cabins. The OKB developed ventilation-type pressure cabins pressurised by engine bleed air which was cooled in air/air heat exchangers; later aircraft made use of cooling turbines to enhance crew comfort.

Another factor reducing the Tu-12's value as a tactical bomber was the lack of a de-icing system for the wing and tail unit leading edges and the cockpit windscreen. This drawback was Tu-2 legacy and was not rectified until the final versions of the Tu-2 family made their appearance.

While cockpit visibility was considered adequate, the State commission recommended a whole range of measures aimed at improving cockpit ergonomics. It also recommended that the navigator/bomb-aimer's station be enlarged in order to give the navigator a better field of view.

One problem which affected all early jets alike manifested itself during the State acceptance trials, namely the tyres' all too short service life. Deficiencies were also discovered in the mainwheel braking system.

The Tu-12 prototype was powered by genuine imported Nenes which generally worked satisfactorily. During the State acceptance trials GK NII VVS undertook a massive research programme to explore engine starting conditions both on the ground and in flight in order to evolve the optimum engine starting techniques and means. This proved useful when the RD-45, the Soviet licence-built version of the Nene, was put into production and when ground support equipment was developed.

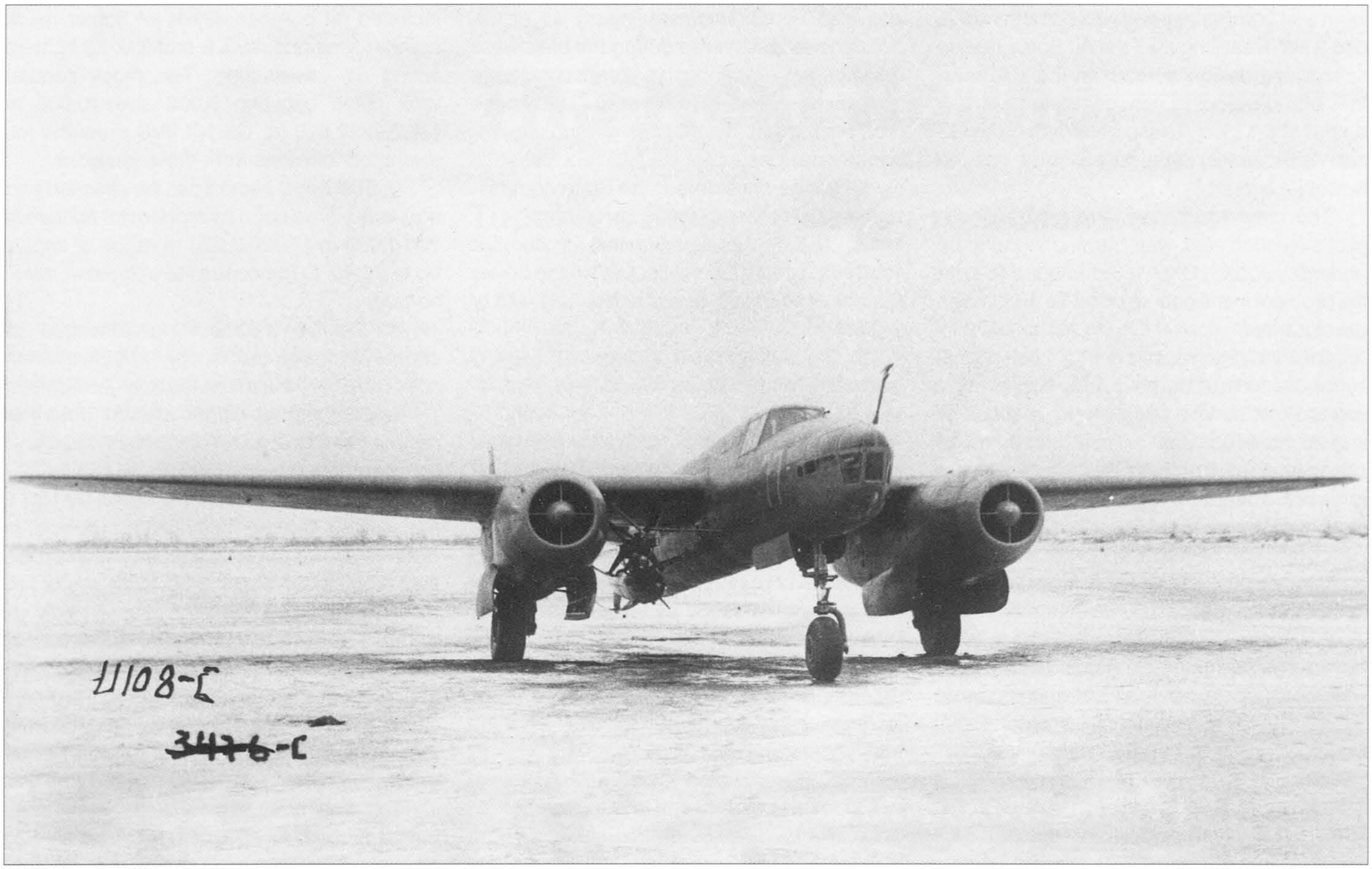
The refuelling system in use until then quickly proved to be inadequate. Whereas the jets had generally a much larger fuel capacity as compared to piston-engined types, they were still refuelled in the traditional manner – by gravity, one tank at a time. As a result, the time needed to refuel the Tu-12 prototype was 1 hour versus 20-25 minutes for its Tu-2 'donor', which of course was unacceptable; ways of significantly cutting turnaround times had to be devised. In the Soviet Union the problem was not cured until the mid/late 1950s when single-point pressure refuelling was introduced on fast jets. As already noted, the fuel leaks which initially plagued the Tu-12 were eliminated in the long run; yet, later jet aircraft developed by the Tupolev OKB made use solely of bladder tanks – until new technologies made it possible to safely use integral tanks on jets.

Tests of the defensive armament revealed that the dorsal and ventral manually trained machine-guns were useless because the high dynamic pressure at the high speeds typical of jet aircraft made it impossible to train the guns! Also, the 12.7-mm calibre of the defensive weapons was deemed inadequate. The State commission recommended using powered barbettes with cannons of at least 20-mm calibre. The forward-firing NS-23 was not much use either, as the cannon's recoil force ruined the mission equipment in the navigator/bomb-aimer's station and even caused the glazing to crack. OKB-156 took all of this into account when developing later jet bombers.

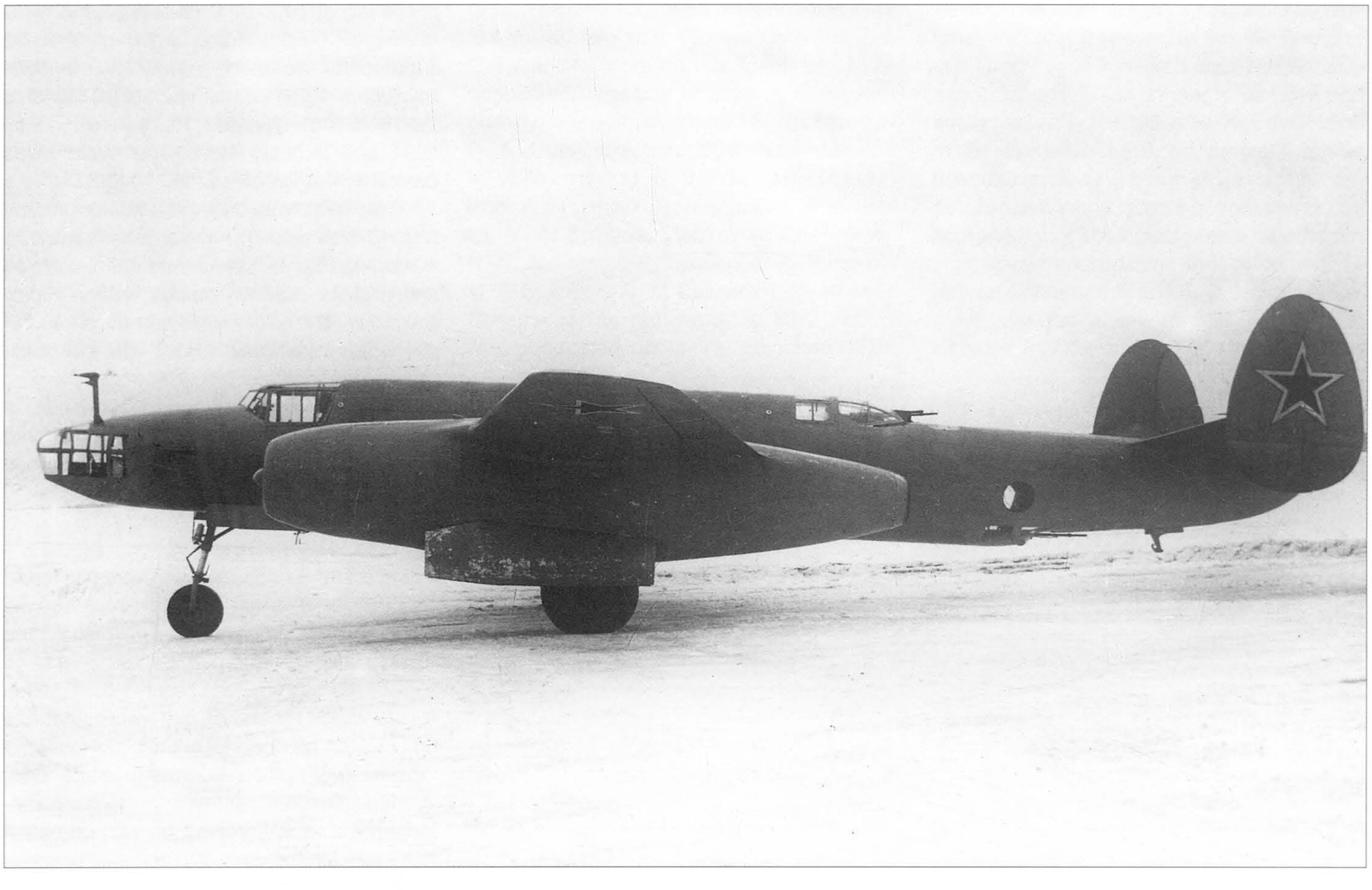
Regarding the bomb armament, the State commission pointed out that the bomb racks needed to be compatible with new advanced models of bombs. Changes were also required to the sighting equipment; in particular, the bomb sight needed to be linked to the autopilot.

As already noted, the Tu-12 prototype entered State acceptance trials with an incomplete avionics and equipment fit. The AP-5 autopilot, the RV-2 radio altimeter and the ARK-5 ADF were all missing, which complicated flying and combat operations. Worse, even the rather limited avionics suite caused problems when it came to finding the best locations for the avionics. Thus, it was established that the IFF transponder disrupted the operation of the communications and command radios. The communications range turned out to be inadequate; the remedy was to install a more powerful RSB-5 radio. GK NII VVS also recommended installing the Ton-2 radar warning receiver.

The new systems and equipment consumed a lot more power than the engine-driven 1.5-kilowatt generators could supply;



Above and below: The same Tu-12 'mother ship' with a different UAV on the underwing pylon. Symbolically, the aircraft is coded '77' to match its manufacturer's designation. Note that the nose cannon has been removed but, oddly enough, the aft-firing machine-guns are still there.



what a jet bomber needed was something like 6 to 9 kW. Realising this, the Air Force tasked specialised design bureaux in the MAP system with developing new generators with an output of 6-12 kW. These generators (the GS and GSR series) later found wide use on Soviet jet aircraft.

The crew rescue system, including the pilot's ejection seat, was likewise found to be underdeveloped. OKB-156 managed to cure the problem in the course of the Tu-14 family's development.

GK NII VVS assessed the Tu-12's suitability for the tactical bomber role. The institute praised the Tu-12's relatively high speed in level flight (which was far greater than that of piston-engined bombers then on the inventory), its adequate service ceiling, rate of climb and range enabling strikes against targets some way beyond the frontlines. The aircraft was described as easy to fly and suitable for operations from unpaved airstrips (providing they were 50-100% larger than those used by the Tu-2S); the better cockpit visibility, which was an asset during formation flying, was also noted. However, nearly all of the deficiencies discovered during the trials were described as rendering the aircraft unsuitable for service use. OKB-156 addressed these problems when developing its subsequent bomber designs.

All things considered, the State commission arrived at the following conclusion:

'1. The Tu-12 experimental jet bomber meets the specifications set forth in the Soviet Council of Ministers' directive No.1805-476 of 31.05.47;

2. The design faults discovered [during the trials] render series production inadvisable;

3. It is advisable to complete the five Tu-12 aircraft currently under construction at plant No.23, transferring them to the Air Force and MAP as research aircraft.'

The commission further recommended that the Tu-12 prototype be retained by GK NII VVS and be used for perfecting the RD-45 turbojet.

Interestingly, for the first time in the Soviet Union the Tu-12's State acceptance trials included jet bomber-versus-jet fighter mock combat sessions, MiG-9 and Yak-23 fighters acting as 'adversaries'. The mock combat took place between 8,000 and 10,000 m (26,250-32,810 ft). GK NII VVS drew the following conclusions from these sessions:

'1. The Tu-12 aircraft can be attacked and accurately fired upon by modern jet fighters at 800-1,000 m [2,620-3,280 ft] *range at angles up to 35-40° to the centreline of the rear hemisphere;*

2. Evasive manoeuvring (changes of course and altitude) is only effective when attacked by low-manoeuvrability jet fighters;

3. Climbing to higher altitude does not reduce the efficiency of jet fighters' attacks; it only hampers the bomber's defensive fire.'

The Tu-12 was also intercepted by MiG-9 and Yak-23 fighters for practice purposes in order to evolve the techniques of intercepting fast targets and using ground-based air defence electronic systems. These 'early jet bomber-versus-early jet fighter' tussles gave valuable data used for developing both the offensive capabilities of fighters and the defensive capabilities of bombers; they also allowed the peculiarities of air combat between different classes of aircraft to be analysed.

Specifications of the '77' (Tu-12) as per State acceptance trials

Powerplant	2 x Klimov RD-45
Take-off thrust, kgp (lbst)	2 x 2,270 (2 x 5,000)
Wing span	18.86 m (61 ft 10½ in)
Length overall	16.445 m (53 ft 11½ in)
Height on ground	4.19 m (13 ft 9 in)
Wing area, m^2 (sq ft)	48.8 (524.73)
Wing aspect ratio	7.3
Landing gear track	6.06 m (19 ft 8$^{19}/_{32}$ in)
Empty weight, kg (lb)	8,993 (19,825)
All-up weight, kg (lb):	
normal	14,700 (32,410)
maximum	15,720 (34,660)
Bomb load, kg (lb):	
normal	1,000 (2,205)
maximum	3,000 (6,610)
Maximum speed, km/h (mph):	
at sea level	778 (483)
at 4,000 m (13,120 ft)	783 (486)
Climb time to 5,000 m (16,400 ft), minutes	8
Service ceiling, m (ft)	11,300 (37,070)
Climb time to service ceiling, minutes	35.6
Take-off run, m (ft)	1,030 (3,380)
Landing run, m (ft)	885 (2,900)
Maximum range with a 1,000-kg bomb load, km (miles):	
at 1,000 m (3,280 ft) and 506 km/h (314 mph)	1,185 (736)
at 5,000 m (16,400 ft) and 540 km/h (335 mph)	1,625 (1,009)
at 8,000 m (26,250 ft) and 560 km/h (347 mph)	2,000 (1,240)
at 10,000 m (32,810 ft) and 564 km/h (350 mph)	2,200 (1,366)
Endurance with a 1,000-kg bomb load:	
at 1,000 m and 506 km/h	2 hrs 25 min
at 5,000 m and 540 km/h	3 hrs 03 min
at 8,000 m and 560 km/h	3 hrs 41 min
at 10,000 m and 564 km/h	4 hrs 01 min
Armament	1 x NS-23 cannon 2 x UBT-12.7 machine-guns
Crew	4

The five production Tu-12s were completed and delivered to the Air Force, serving as conversion trainers for bomber pilots transitioning to jet aircraft. They remained operational until the early 1950s; for instance, the pilot's log of Tupolev OKB test pilot Yuriy T. Alasheyev (killed in the crash of a Tu-22 supersonic bomber prototype on 25th December 1959) contains about 20 flights in the Tu-12 prototype (the '77/1') between May 1951 and January 1952. The aircraft was owned by the Tupolev OKB.

One Tu-12 was converted into an engine testbed (see below), while another served as a 'mother ship' for unmanned aerial vehicles and rockets used in various research programmes. The UAVs were carried on a special beam-type rack under the starboard wing's root section.

The experience gained by OKB-156 in developing and testing the Tu-12 proved invaluable when developing more advanced jet aircraft, civil as well as military.

Tu-12LL engine testbed

A single Tu-12 (c/n unknown) was converted into a testbed for the RD-550 ramjet engine. Developed by Mikhail M. Bondaryuk, the RD-550 was intended to power the LM-15 supersonic target drone designed by Matus R. Bisnovat. The development engine was mounted in an unconventional manner on a forward-swept pylon atop the fuselage. Designated Tu-12LL (*le**ta**yuschchaya labora**to**riya*), the aircraft served on with LII until it was retired in the early 1950s.

Chapter 7

The Next Round

Tupolev's Steps Towards Production Bombers

As noted earlier, the Tupolev OKB's first jet aircraft – the Tu-12 ('77') – was primarily an experimental aircraft developed within a very tight schedule by modifying the production Tu-2 bomber. It was used basically for verifying the new powerplant type.

A somewhat different approach was practised when designing medium bombers and high-altitude reconnaissance aircraft (the '74' and '76' aircraft). Here an attempt was made to make use of a mixed powerplant comprising two wing-mounted radial engines and one turbojet engine installed in the rear fuselage. However, complications resulting from the need to ensure joint functioning of engines of a different kind compelled the designers to give up this technical feature.

The second jet aircraft submitted for testing by OKB-156 in October 1947 was a three-engined medium bomber prototype which was developed under the in-house designation '73'. This machine formed the basis for the future Tu-14 aircraft family: the '78' reconnaissance aircraft prototype, the twin-engined production versions (the Tu-14 bomber and the Tu-14T torpedo-bomber), as well as for the '89' reconnaissance aircraft prototype and several other projects.

The work on the Tu-14 family yielded a lot of useful information which was subsequently used in the design of more advanced jet bombers. The Tu-14T torpedo-bomber which had entered series production became the first heavy turbojet-powered combat aircraft to be operated by the Soviet Naval Air Arm (AVMF – *Avi**ah**tsiya Vo**yen**no-mor**sko**vo **flo**ta*). This machine facilitated in many respects the Naval Air Arm's transition to new jet hardware and played a considerable role in preparing naval pilots for conversion to the Tu-16 bombers and missile carrier aircraft.

For Tupolev's OKB the Tu-14 was the first turbojet-powered machine to achieve series production, after a five-year period of development and redesign.

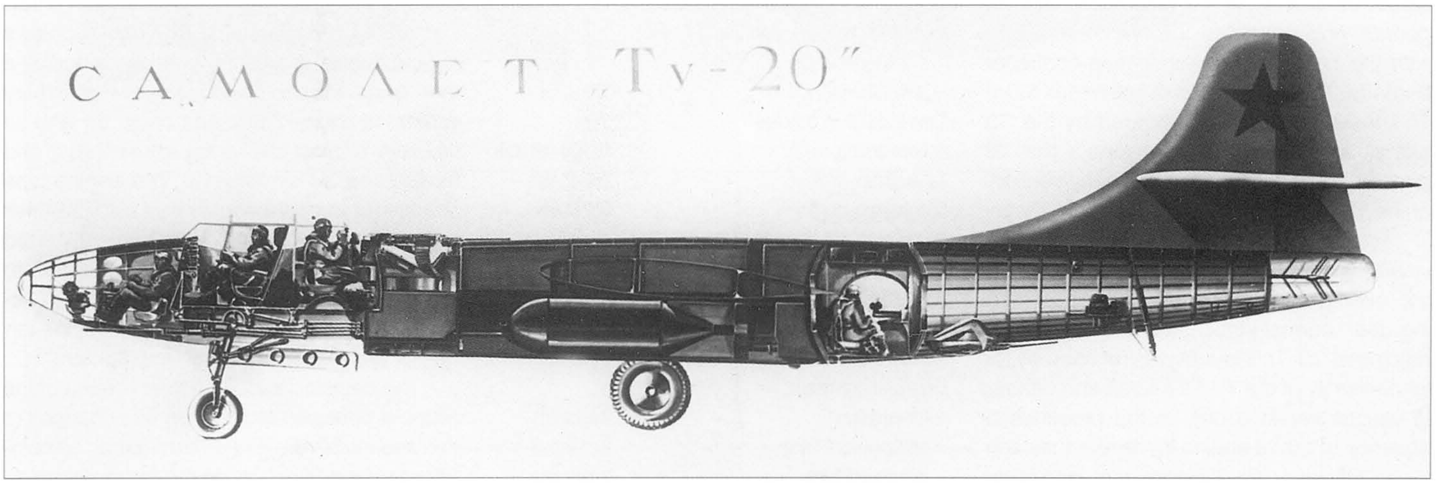
Design work and construction of prototype aircraft of the Tu-14 family were conducted under the guidance of Andrey N. Tupolev and his aides – Aleksandr A. Arkhangel'skiy, N. I. Bazenkov, Leonid L. Kerber, Dmitriy S. Markov, K. V. Minckner, G. A. Ozerov and A. M. Cheryomukhin.

Introduction of the machine into series production at Plant No.23 in Moscow was the responsibility of N. I. Bazenkov, while Pavel O. Sukhoi performed the same duties with regard to Plant No.39 in Irkutsk. (After his design bureau had been disbanded in 1949, Sukhoi worked with Tupolev until 1953.) At OKB-156 the work on the Tu-14 family was conducted by teams headed by B. M. Kondorskiy, Sergey M. Yeger, S. I. Savelyev, D. A. Gorskiy, Aleksandr V. Nadashkevich, N. V. Kirsanov, M. N. Petrov, T. P. Saprykin, Boris A. Saukke, K. P. Sveshnikov, A. E. Sterlin, N. A. Sokolov, Vladimir A. Chizhevskiy, N. S. Nekrasov, B. S. Ivanov, A. R. Bonin, M. I. Biryukov, A. P. Baluyev, I. M. Kostkin. Construction of prototypes at MMZ No.156 was conducted under the guidance of the Plant's director I. B. Iosipovich, chief engineer A. V. Meshcheryakov, chief metallurgist I. P. Golovin and chief production engineer S. A. Vigdorchik. Development of all prototype aircraft, their ground and flight testing was conducted under the guidance of the OKB's flight test facility chief Ye. K. Stoman together with project engineers B. N. Grozdov, M. M. Yegorov and M. L. Mel'nikov. The aircraft were tested by crews captained by OKB-156 test pilots Fyodor F. Opadchiy and Aleksey D. Perelyot.

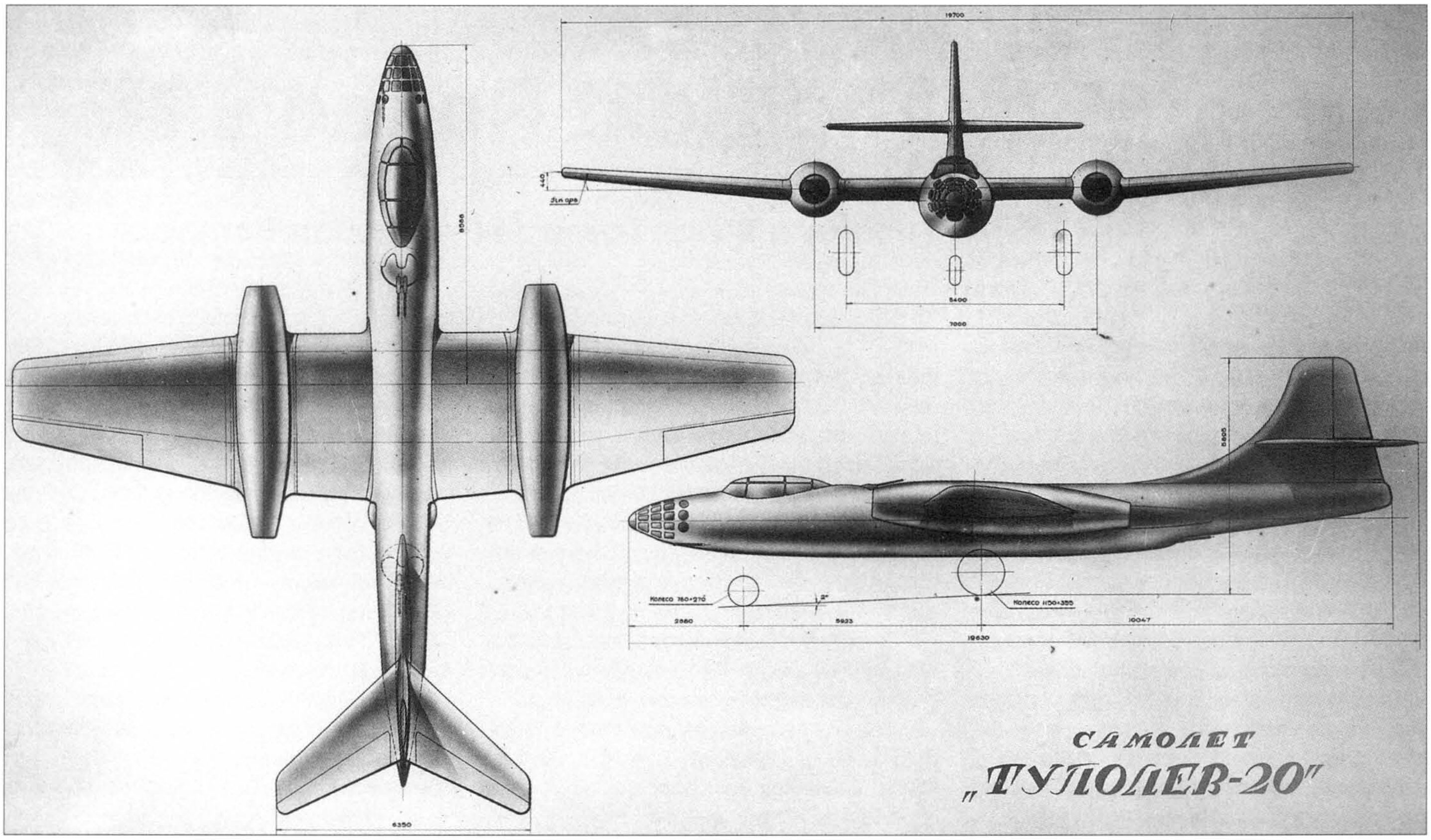
Dmitriy S. Markov was in charge of the programme in the course of series manufacture and operational service of the Tu-14 bombers and the Tu-14T torpedo-bombers.

'73' (Tu-20) medium bomber (project)

OKB-156 started design work on the '73' aircraft in January 1947. This medium bomber powered by two Rolls-Royce Nene I engines received the tentative official designation Tu-20. (This was the first use of the Tu-20 designation. Later it passed to the '79' bomber; still later it was reserved (but not actually used) for the Tu-95 strategic bomber and finally revived in the 1990s as the designation of an executive transport project.) It was intended for dealing bomb strikes against targets located in the theatre of operations' tactical and minor strategic zones. The intended high speed approaching that of contemporary jet fighters, the potent defensive armament and the ability to fulfil missions at altitudes in excess of 10,000 m (32,810 ft)



A cutaway drawing of the '73' (Tu-20) bomber as originally developed in twinjet configuration. Note the lateral sighting blisters of the ventral gunner's compartment immediately aft of the wings.



A three-view of the '73' (Tu-20) from the original project, showing the Gloster Meteor-style engine nacelles and the main gear units retracting into the wing roots. One might be tempted to call it the 'Soviet Canberra' (the similarity is obvious, especially in the wing area), but the English Electric Canberra did not exist then!

enabled the '73' aircraft to deal strikes against the most heavily protected facilities of a potential adversary. The high combat efficiency of the '73' aircraft was to be ensured by its ability to carry internally bombs weighing up to 3,000 kg (6,610 lb) apiece.

The bomber was to be used for both day and night operations in adverse weather conditions. The crew of four was to be accommodated in two pressure cabins, the fuselage featuring a layout similar to that of the '72' bomber described in the previous chapter. The forward cabin provided accommodation for the pilot, the navigator and the gunner/radio-operator who manned the dorsal turret. Seated in the rear cabin was the gunner who protected the rear hemisphere with the help of a ventral remote-controlled barbette. The project envisaged no tail turret. This fuselage layout was shared by the '73' aircraft and its modified versions – the '78' and '79' aircraft, as well as the early versions of the '81' aircraft project.

At the initial design stage the '73' bomber was a twin-engined monoplane with a high-set unswept wing, three-unit nosewheel landing gear, normal vertical tail and swept-back horizontal tail. This layout was retained by the whole family of the Tu-14 aircraft and differed in various versions only in the presence or absence of a third engine in the rear fuselage.

In February 1947 preliminary inspection of the full-scale mock-up of the '73' aircraft took place, whereupon detail design work started. On 10th March a commission from GK NII VVS inspected the mock-up for the second time and made some recommendations concerning modifications that were to be effected on the mock-up.

On 11th March 1947 the Council of Ministers issued Directive No.493-192 which endorsed the construction of the Tu-20 bomber prototype and stipulated that the machine be submitted for State acceptance trials in December of that year. Under the terms of the Directive, the Tu-20 powered by two Nene-1 engines was to possess the following performance:

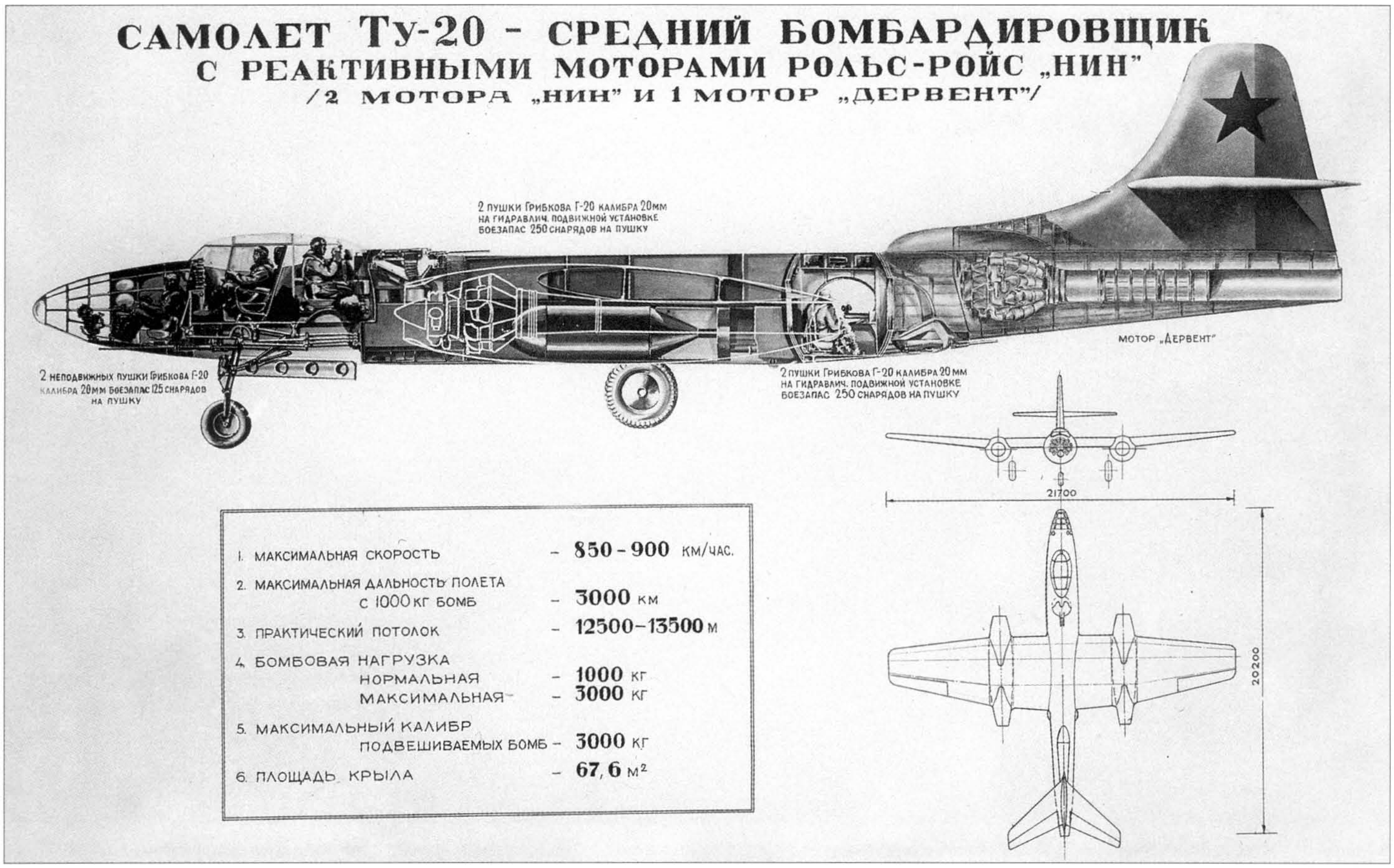
Maximum level flight speed, km/h (mph):	
at sea level	800 (497
at 5,000 m (16,400 ft)	850 (528)
Time to 5,000 m, minutes	5.5
Service ceiling, m (ft)	12,200 (40,030)
Take-off run, m (ft)	750 (2,460)
Landing run, m (ft)	600 (1,968)
Range at an altitude of 10,000 m (32,800 ft):	
with a bomb load of 1,000 kg (2,205 lb), km (miles)	3,000 (1,864)
Normal bomb load, kg (lb)	1,000 (2,205)
Maximum bomb load, kg (lb)	3,000 (6,615)
Defensive armament:	
forward-firing	2 cannons
aft/downward-firing	2 cannons
aft/upward-firing	2 cannons
Cannon calibre, mm	23

The Nene I engines delivered from Britain developed a static thrust of 2,000 kgp (4,410 lbst) at sea level instead of the 2,270 kgp (5,000 lbst) stated by the Rolls-Royce Company. Thorough calculations performed at the ADP stage showed that the Tu-20 powered by two Nene I engines would not meet the performance stipulated by the Directive. The OKB had to start work on a new version of the '73' bomber.

'73' (Tu-14) medium bomber prototype

Having commenced studies on a new version of the '73', the designers hit upon an unorthodox solution which, according to calculations, held the promise of attaining the required performance characteristics. At A. N. Tupolev's suggestion a decision was taken to install a third engine in the rear fuselage. Preliminary estimates showed that one could do with an auxiliary engine delivering lower thrust and having smaller dimensions. The engine type chosen for the third engine was also of British origin; it was the Rolls-Royce Derwent V rated at 1,640 kgp (3,620 lbst) at sea level. It was to be started only for take-off or when it was necessary to put on a burst of speed (over the target, or in order to outrun enemy fighters).

The decision to build a trijet version of the bomber necessitated appropriate changes to the technical drawings, additional calculations and modifications to the full-scale mock-up. Construction if the new mock-up of the

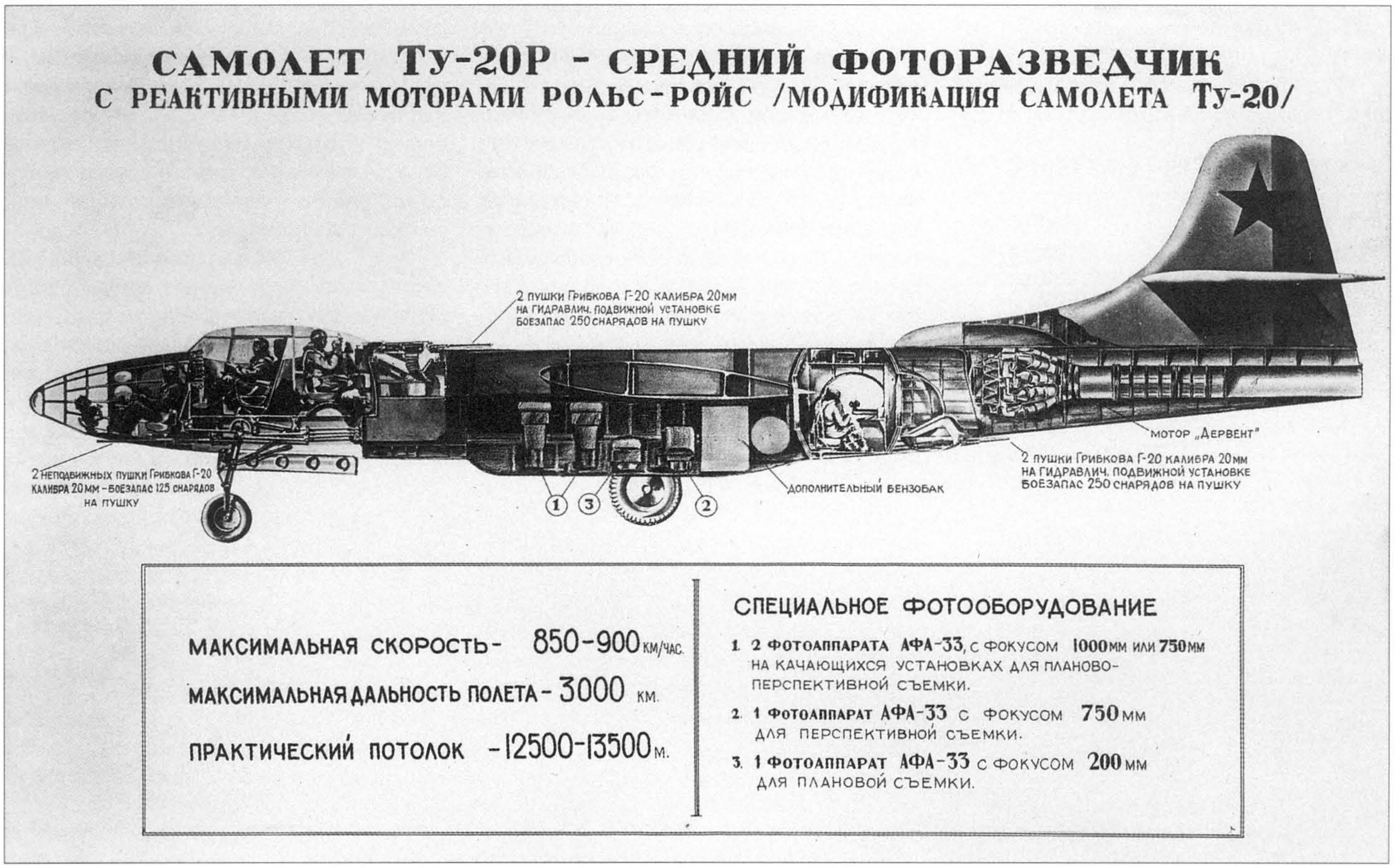


САМОЛЕТ ТУ-20 - СРЕДНИЙ БОМБАРДИРОВЩИК
С РЕАКТИВНЫМИ МОТОРАМИ РОЛЬС-РОЙС „НИН"
/2 МОТОРА „НИН" И 1 МОТОР „ДЕРВЕНТ"/

1. МАКСИМАЛЬНАЯ СКОРОСТЬ	-	850 - 900 КМ/ЧАС.
2. МАКСИМАЛЬНАЯ ДАЛЬНОСТЬ ПОЛЕТА С 1000 КГ БОМБ	-	3000 КМ
3. ПРАКТИЧЕСКИЙ ПОТОЛОК	-	12500–13500 М
4. БОМБОВАЯ НАГРУЗКА НОРМАЛЬНАЯ	-	1000 КГ
МАКСИМАЛЬНАЯ	-	3000 КГ
5. МАКСИМАЛЬНЫЙ КАЛИБР ПОДВЕШИВАЕМЫХ БОМБ	-	3000 КГ
6. ПЛОЩАДЬ КРЫЛА	-	67,6 М²

2 ПУШКИ ГРИБКОВА Г-20 КАЛИБРА 20ММ НА ГИДРАВЛИЧ. ПОДВИЖНОЙ УСТАНОВКЕ БОЕЗАПАС 250 СНАРЯДОВ НА ПУШКУ
2 НЕПОДВИЖНЫХ ПУШКИ ГРИБКОВА Г-20 КАЛИБРА 20ММ БОЕЗАПАС 125 СНАРЯДОВ НА ПУШКУ
2 ПУШКИ ГРИБКОВА Г-20 КАЛИБРА 20 ММ НА ГИДРАВЛИЧ. ПОДВИЖНОЙ УСТАНОВКЕ БОЕЗАПАС 250 СНАРЯДОВ НА ПУШКУ
МОТОР „ДЕРВЕНТ"
21700
20200

Above: A drawing of the '73' (Tu-20) in the revised configuration with two Nene I main engines and a Derwent V booster engine breathing through an intake in the dorsal fin. The engine nacelles are now underslung instead of passing through the wing spars, but the main gear units still retract inwards into the wing roots.



САМОЛЕТ ТУ-20Р - СРЕДНИЙ ФОТОРАЗВЕДЧИК
С РЕАКТИВНЫМИ МОТОРАМИ РОЛЬС-РОЙС /МОДИФИКАЦИЯ САМОЛЕТА ТУ-20/

МАКСИМАЛЬНАЯ СКОРОСТЬ - 850-900 КМ/ЧАС.

МАКСИМАЛЬНАЯ ДАЛЬНОСТЬ ПОЛЕТА - 3000 КМ.

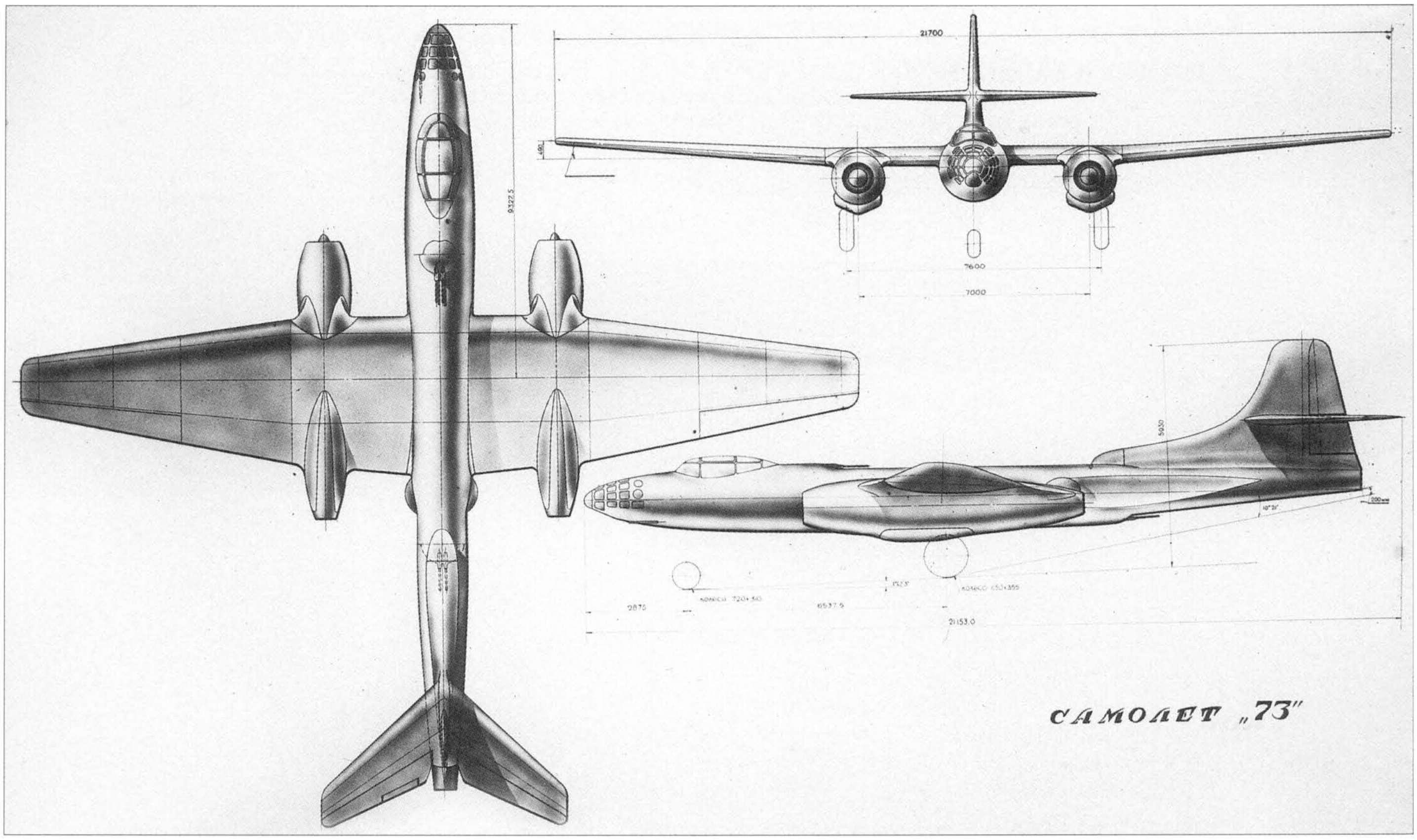
ПРАКТИЧЕСКИЙ ПОТОЛОК - 12500-13500 М.

СПЕЦИАЛЬНОЕ ФОТООБОРУДОВАНИЕ

1. 2 ФОТОАППАРАТА АФА-33, С ФОКУСОМ 1000 ММ ИЛИ 750 ММ НА КАЧАЮЩИХСЯ УСТАНОВКАХ ДЛЯ ПЛАНОВО-ПЕРСПЕКТИВНОЙ СЪЕМКИ.
2. 1 ФОТОАППАРАТ АФА-33 С ФОКУСОМ 750 ММ ДЛЯ ПЕРСПЕКТИВНОЙ СЪЕМКИ.
3. 1 ФОТОАППАРАТ АФА-33 С ФОКУСОМ 200 ММ ДЛЯ ПЛАНОВОЙ СЪЕМКИ.

2 ПУШКИ ГРИБКОВА Г-20 КАЛИБРА 20ММ НА ГИДРАВЛИЧ. ПОДВИЖНОЙ УСТАНОВКЕ БОЕЗАПАС 250 СНАРЯДОВ НА ПУШКУ
2 НЕПОДВИЖНЫХ ПУШКИ ГРИБКОВА Г-20 КАЛИБРА 20 ММ - БОЕЗАПАС 125 СНАРЯДОВ НА ПУШКУ
МОТОР „ДЕРВЕНТ"
2 ПУШКИ ГРИБКОВА Г-20 КАЛИБРА 20 ММ НА ГИДРАВЛИЧ. ПОДВИЖНОЙ УСТАНОВКЕ БОЕЗАПАС 250 СНАРЯДОВ НА ПУШКУ
ДОПОЛНИТЕЛЬНЫЙ БЕНЗОБАК
①
③
②

A drawing of the projected Tu-20R trijet photo reconnaissance version. The long lenses of the cameras and the limited depth of the camera bay have necessitated provision of a large ventral fairing, giving the aircraft a pregnant look; the camera bay also houses a long-range fuel tank.



A three-view of the definitive version of the '73' bomber with the main engines placed closer to the fuselage and main gear units retracting forward into the engine nacelles

'73' aircraft started on 23rd May; the changes introduced were endorsed by the GK NII VVS mock-up review commission between 24th and 28th May.

On 14th June the OKB sent the revised advanced development project of the '73' featuring the new powerplant to GK NII VVS. The design specifications of this version are detailed in the table on this page.

Design specifications of the '73' as of 14th July 1947

Length overall	21.15 m (69 ft 4⅝ in)
Height on ground	5.93 m (19 ft 5½ in)
Wing span	27.1 m (88 ft 11 in)
Wing area, m² (sq ft)	67.36 (725)
Normal AUW, kg (lb)	16,900 (37,260)
Overload AUW, kg (lb)	21,140 (46,610)
Empty weight, kg (lb)	11,580 (25,530)
Maximum level flight speed at 8,000 m (26,250 ft), km/h (mph)	850 (528)
Time to 5,000 m (16,400 ft), minutes	5.5
Service ceiling, m (ft)	12,000 (39,360)
Take-off run, m (ft)	750 (2,460)
Landing run, m (ft)	600 (1,968)
Range at 10,000 m (32,810 ft) with a bomb load of 1,000 kg (2,205 lb), km (miles)	3,000 (1,864)
Bomb load, normal, kg (lb)	1,000 (2,205)
maximum, kg (lb)	3,000 (6,615)
Defensive armament:	
forward-firing	2 cannons
aft/downward-firing	2 cannons
aft/upward-firing	2 cannons
Cannon calibre, mm (in)	23 (.90 in)
Crew	4

Design work on the '73' aircraft was completed in July 1947, and manufacturing drawings were issued in the third quarter of the year. At the same time construction of the prototype commenced at MMZ No.156 in Moscow. The manufacture of all parts, units and assemblies of the aircraft was initiated in August. The construction of the machine proceeded at a speedy rate. Also in August 1947 the '73' was allocated the new official designation Tu-14.

While designing the '73' bomber the engineers of OKB-156 succeeded in resolving a number of important issues which determined the subsequent development of Soviet jet bomber aviation to a considerable extent.

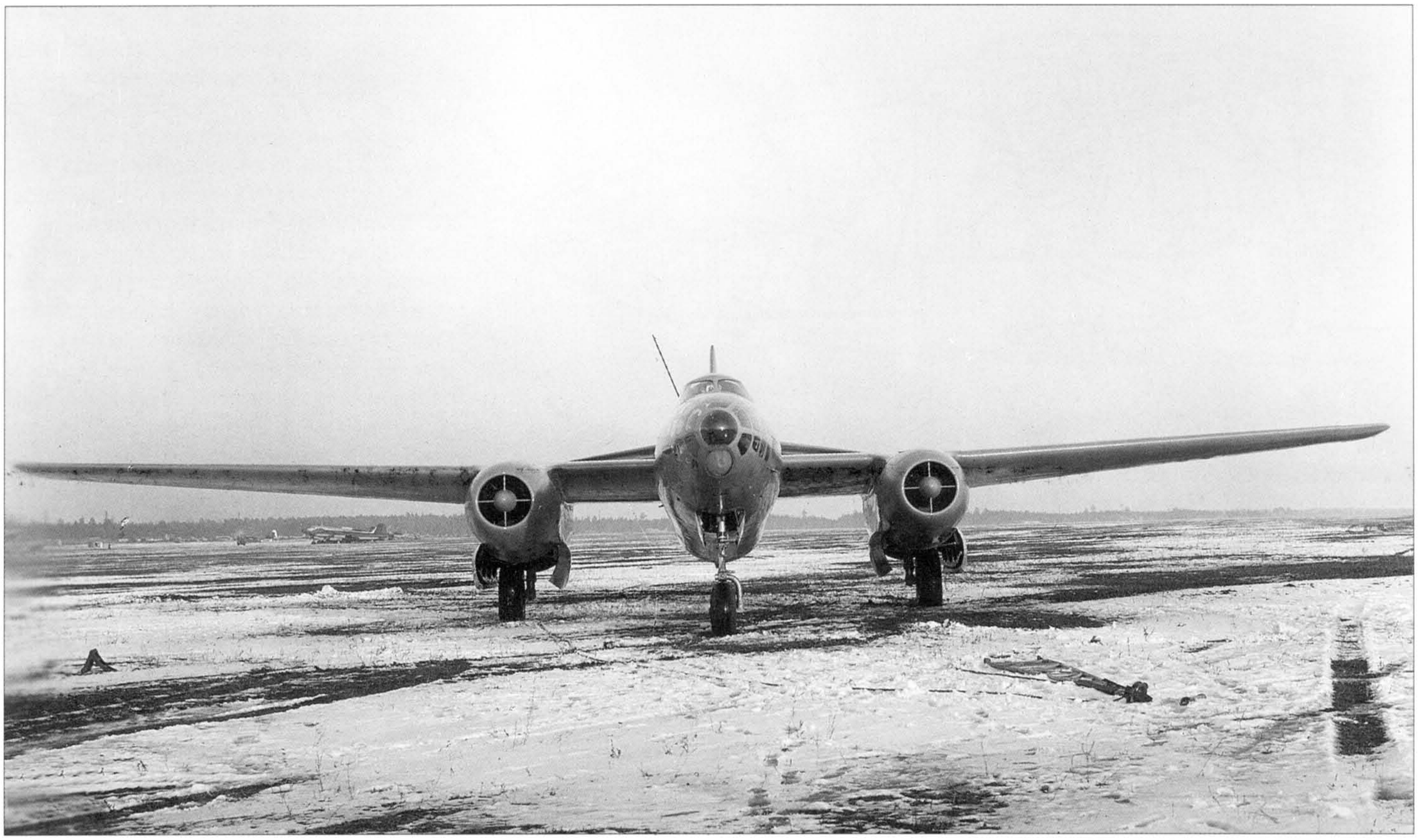
Calculations performed by the OKB showed that the optimum flight profile of a turbojet-powered aircraft is flight at altitudes close to the service ceiling. This conclusion dictated the need for pressurised crew cabins; the aircraft was to be provided with pressurisation and air conditioning systems enabling it to fly at altitudes of 10,000-12,000 m (32,810-39,360 ft).

A matter of particular interest was the location of the third engine. Its air intake was placed on top of the rear fuselage and was so designed that its outer contours blended into the dorsal fin. Initially this configuration of the air intake provoked some doubts due to the risk of ingestion of the fuselage boundary layer, which could provoke engine surge. Experiments with air intake models in TsAGI wind tunnels followed by flight testing showed that this air intake functioned very efficiently during flights at high subsonic speeds because the wing downwash sucked the turbulent boundary layer away from the upper surface of the fuselage.

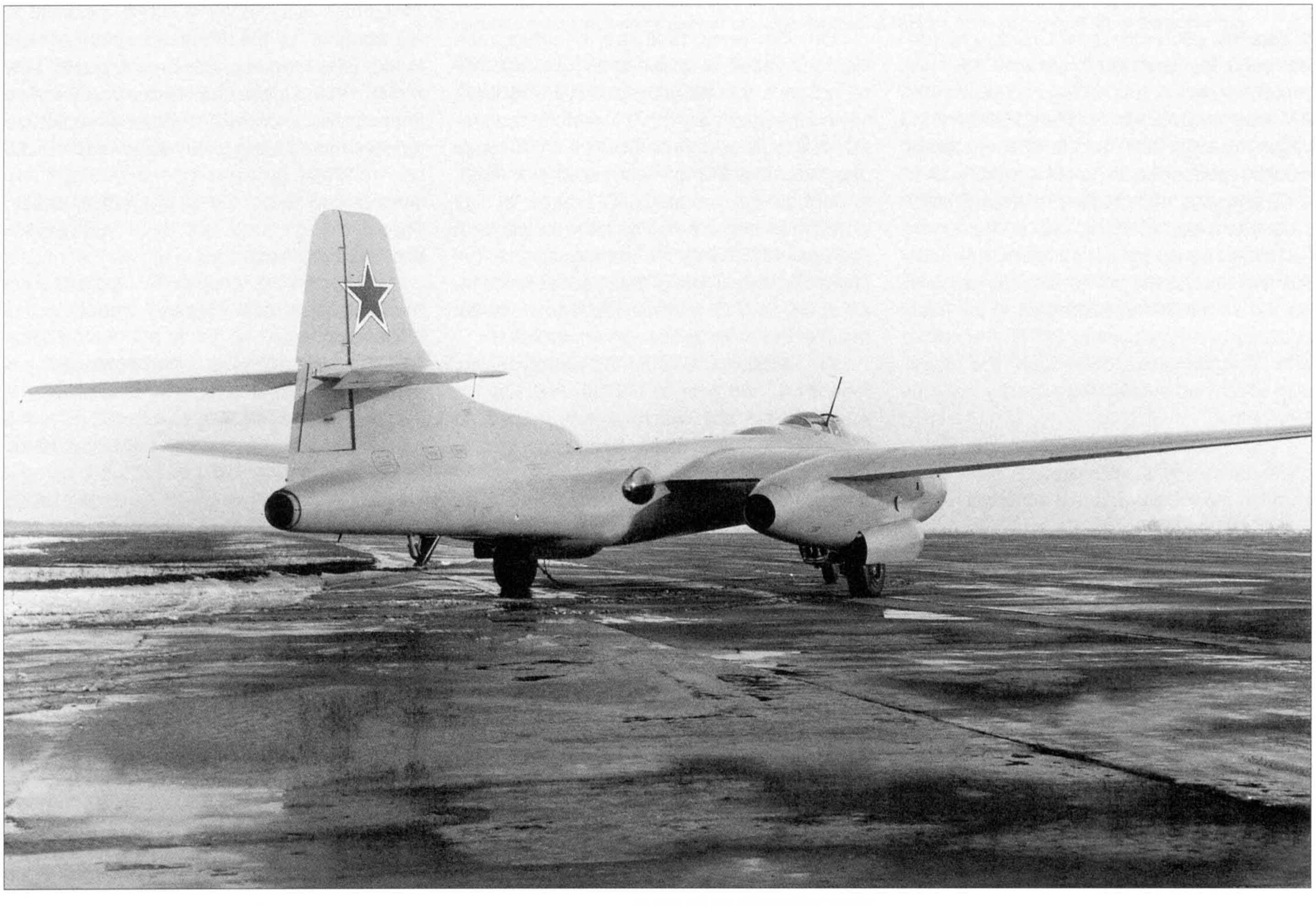
The '73' aircraft was designed as a modern jet bomber with a potent complement of offensive and defensive armament and with sufficiently high performance characteristics. A serious deficiency of the project consisted in the absence of an onboard radar for precision bombing in poor target visibility conditions, which reduced the aircraft's combat efficiency. The compact and lightweight PSBN radar (*pri**bor** sle**po**vo bombome**tah**niya i navi**gah**tsiï* – blind bombing and navigation device) was still on the drawing boards, and the *Ko**bal't*** (Cobalt) bomb aiming radar installed in the Tu-4 was too bulky for a medium bomber.

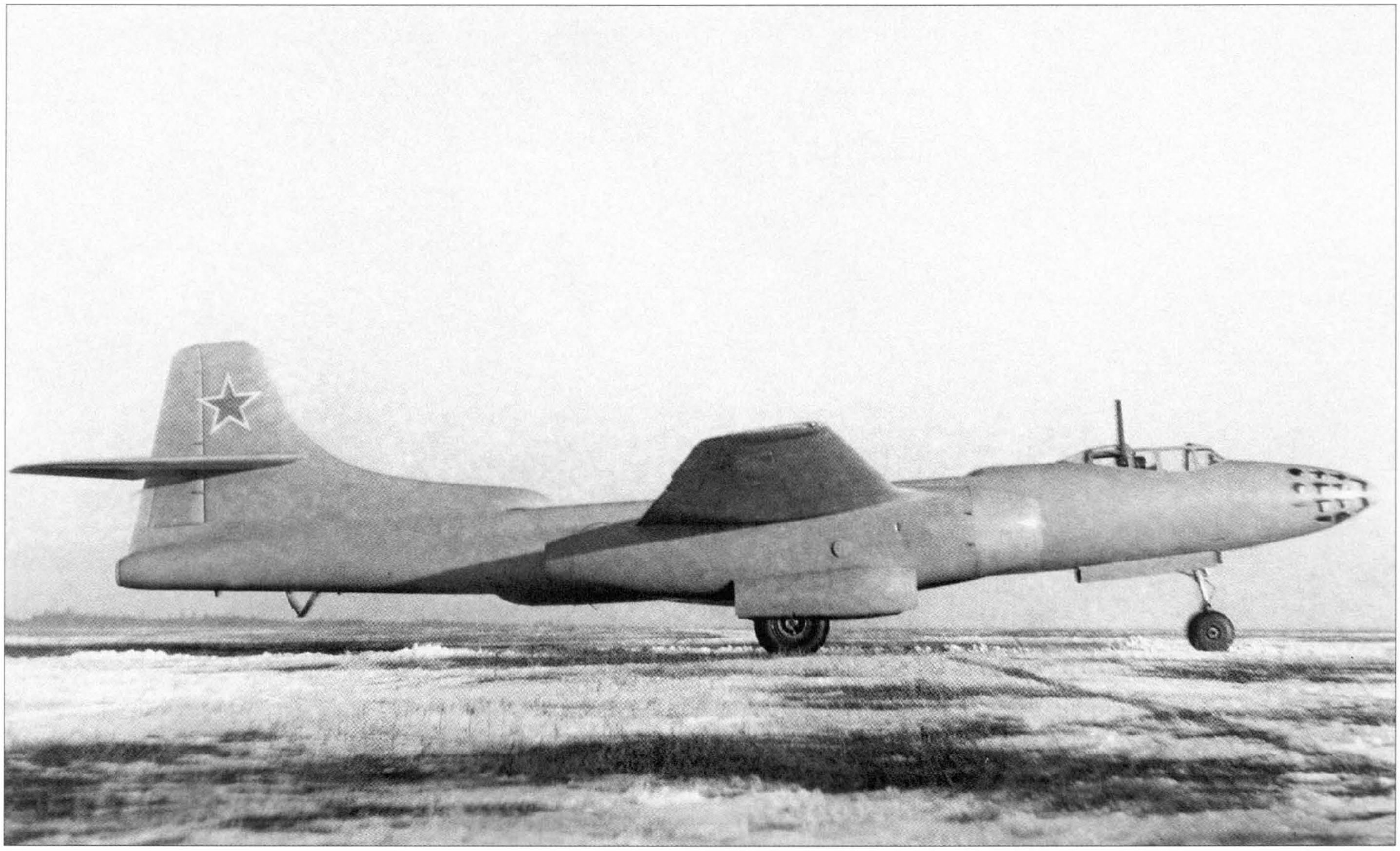
The prototype of the '73' aircraft was rolled out in October 1947; no cannon barbettes were installed yet. On 29th October the machine was trucked from MMZ No.156 to the OKB's flight test facility in Zhukovskiy.

Manufacturer's flight tests of the bomber lasted from 29th October 1947 to 14th June 1948. Fyodor F. Opadchiy was appointed



Above and below: The first prototype of the '73' (Tu-14) bomber at Zhukovskiy during manufacturer's flight tests. These views show the air intake bullet centrebodies with cruciform struts, the outer wing dihedral and the semi-recessed lateral sighting blisters. No cannon barbettes are fitted yet.





A side view of the first prototype '73' (Tu-14), showing the swept horizontal tail and the retractable tail bumper. The aircraft had a characteristic nose-up attitude. The intake of the centre engine is closed by a retractable fairing.

project test pilot, with B. N. Grozdov as project engineer. On 14th November 1947 the aircraft moved under its own power for the first time; high-speed runs and short hops began five days later. On 20th December the machine performed its first real flight.

During the manufacturer's tests the '73' prototype made 46 flights; ten of these were performed during preparations for the annual Tushino Air Display in the summer of 1948. Yet the aircraft did not take part in the event because of an incident which had occurred with its reconnaissance version, the'78' aircraft which had entered flight test by that time (see below).

The dimensions and basic performance characteristics of the '73' stated below come from the manufacturer's test materials.

Wing span	21.7 m (71 ft 2⅜ in)
Length overall	20.32 m (66 ft 8 in)
Height on ground	5.93 m (19 ft 5½ in)
Wing area, m^2 (sq ft)	67.38 (725)
Normal AUW, kg (lb)	18,151 (40,020)
Overload AUW, kg (lb)	23,917 (52,740)
Empty weight, kg (lb)	13,660 (30,120)
Maximum level flight speed at 6,000 m (19,685 ft), km/h (mph)	870 (541)
Time to 10,000 m (32,810 ft), minutes	21.3
Range with a 1,000-kg (2,205-lb) bomb load, km (miles)	2,966 (1,843)

On 25th June 1948 the manufacturer's flight test report was sent to GK NII VVS. The report gave the aircraft a positive appraisal, saying that generally the '73' met the requirements stipulated by the Council of Ministers directive. The bomber was stable in flight throughout the operational CG range, and its simple handling made it suitable for pilots of average skill. It was recommended that the aircraft be submitted for State acceptance trials at GK NII VVS with the subsequent installation of the missing cannon armament.

On 14th June 1948 the '73' prototype was formally turned over to GK NII VVS. On 7th August 1948 the machine was ferried to Chkalovskaya AB near Shcholkovo town about 30 km (18.5 miles) east of Moscow, where Stage A of the State acceptance trials took place between 10th August and 1st October. Only six flights were performed during that period, with Mikhail A. Nyukhtikov as test pilot. Due to the poor functioning of the Nene I engines and the fuel system the tests were suspended and no performance characteristics were determined.

The aircraft was returned to MMZ No.156 where it underwent development and modifications between 1st October and 31st December 1948 (among other things, the main engines' fuel filters were replaced). On 3rd January 1949 the bomber was ready to resume the trials.

Stage B of the State acceptance trials took place between 6th January and 31st March 1949. Quoted below are performance characteristics of the '73' bomber prototype as determined during this stage of the trials.

Normal AUW, kg (lb)	20,100 (44,320)
Overload AUW, kg (lb)	24,200 (53,361)
Maximum level flight speed at 5,000 m (16,400 ft), km/h (mph)	872 (542)
Time to 5,000 m (16,400 ft), minutes	9.5
Service ceiling, m (ft)	11,500 (37,720)
Take-off run with JATO rockets, m (ft)	740 (2,428)
Landing run, m (ft)	1,170 (3,839)
Range with a 1,000-kg (2,205-lb) bomb load, km (miles)	2,810 (1,746)
Bomb load, kg (lb):	
normal	1,000 (2,205)
maximum	3,000 (6,610)

Proceeding from the State acceptance trials results, GK NII VVS concluded that the performance of the Tu-14 ('73') basically met the requirements stipulated by the CofM directive dated 31st May 1947, except that the range was 190 km (118 miles) shorter than required. The Protocol on the State acceptance trials results noted the following substantial deficiencies of the bomber prototype:

- absence of radar aiming and radio navigation means for bombing without direct visibility of the earth;

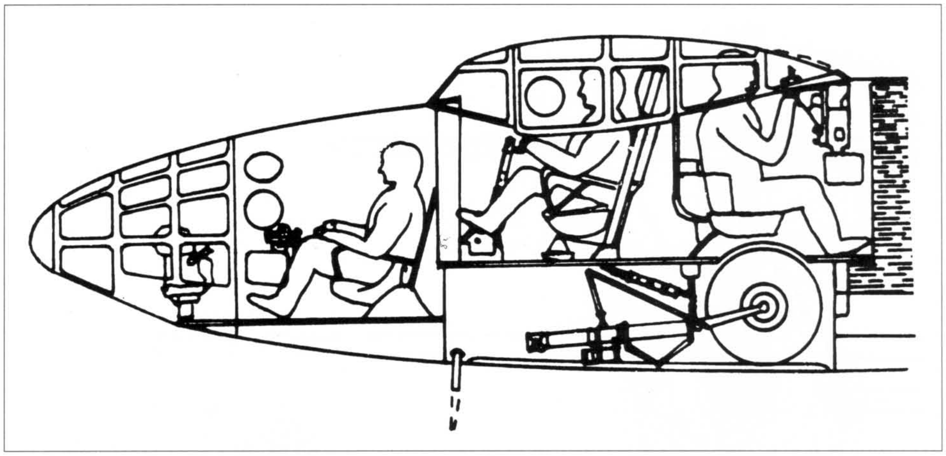
- insufficient armour protection for the crew (especially from beneath);
- absence of anti-icers on the wing and tail unit leading edges;
- the use of two different engine types;
- excessive pressure in the wheel tyre tubes.

In addition to these remarks from GK NII VVS one could mention the long take-off run without JATO rockets and the long landing run. As it appears from the commission's conclusion, the customer transferred the Tu-14 medium bomber into the tactical bomber class, albeit the aircraft had not been intended to meet the characteristics of this class.

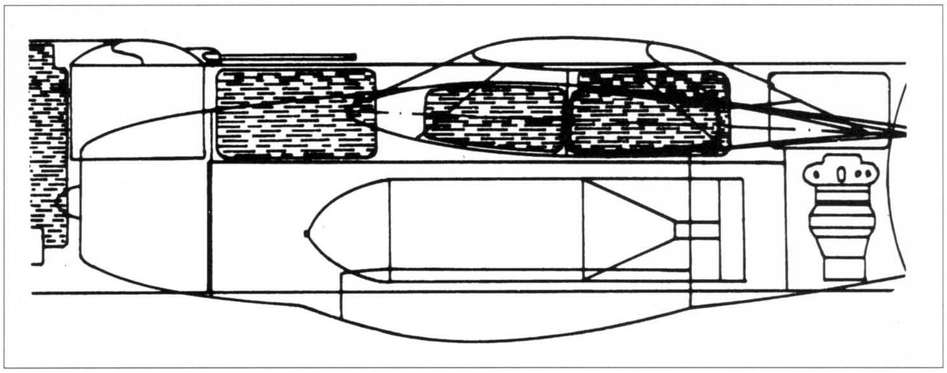
The State acceptance trials were completed in late May 1949. By then the Air Force had a realistic alternative to the Tu-14; it was the IL-28 tactical bomber. Powered by two RD-45F turbojets, the IL-28 was lighter and was already in production. The emergence of a successful competitor coupled with the fairly long list of deficiencies put the further prospects of the Tu-14 ('73') in jeopardy.

However, even before the completion of the manufacturer's tests, the question of putting the '73' into production (under the in-house designation '73S', the S standing for *se**reey**nyy* – production, used attributively) had been resolved by MAP order No.194 issued on 9th April 1948. Pursuant to Council of Ministers directive No.791-256 dated 15th March 1948, Plant No.23 at Moscow-Fili was tasked with building a pre-series batch of ten '73' aircraft powered by Klimov RD-45 and RD-500 engines (the Soviet versions of the RR Nene I and Derwent V respectively). The nation's leaders were so confident the new aircraft would be a success that as early as 5th May 1948 the Council of Ministers issued a new directive (No.1623-632), followed up by MAP order No.331 of 27th May, which tasked Plant 23 with launching full-scale production of the Tu-14 on the basis of the '73' prototype.

To speed up the aircraft's production entry, on 28th July 1948 MAP issued an additional order No.544 under the terms of which a group of 50 Tupolev OKB employees headed by Deputy Chief Designer N. I. Bazenkov and his assistant A. Ya. Shakhov was sent to the production plant. The plant manufactured a certain quantity of parts and assemblies for the first production batch of Tu-14 bombers, but on 14th May 1949 the Council of Ministers issued yet another directive (No.1890-700) on the results of state acceptance trials of the Tu-14 and IL-28 aircraft, which cancelled the decision to start series production of the Tu-14. Subsequently the backlog of parts manufactured at Plant No.23 was transferred to Plant No.39 in Irkutsk where it was used for manufacturing the '81' torpedo-bombers.



Above: The layout of the '73' (Tu-14) prototype's forward crew compartment. The navigator moved forward to a special jump seat to use the bomb sight; the gunner used an ordinary (not periscopic) sight.



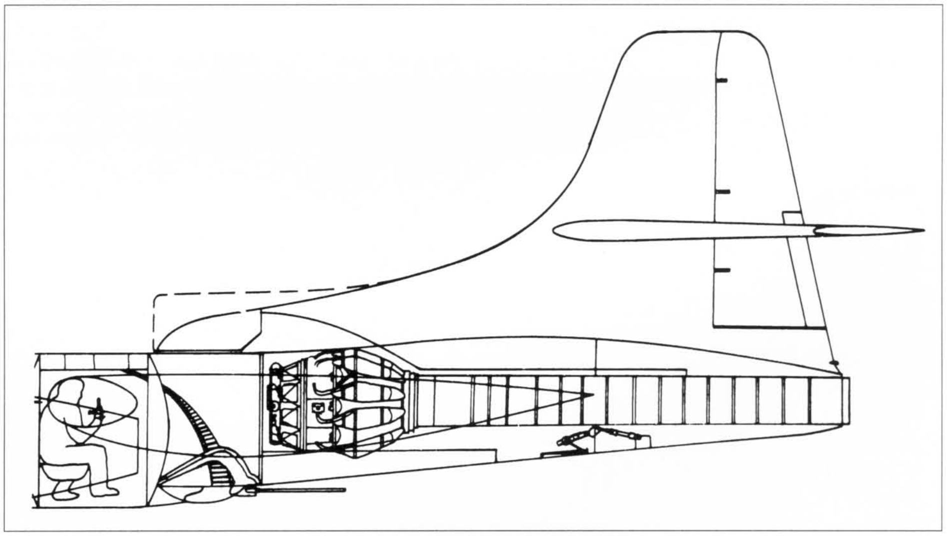
The bomb bay of the '73' could take a 3,000-kg bomb. Note the fuel tanks fore and aft of the dorsal barbette and in the wing centre section torsion box. A strike camera is located aft of the bomb bay.

Structural description of the '73' (as per ADP documents)

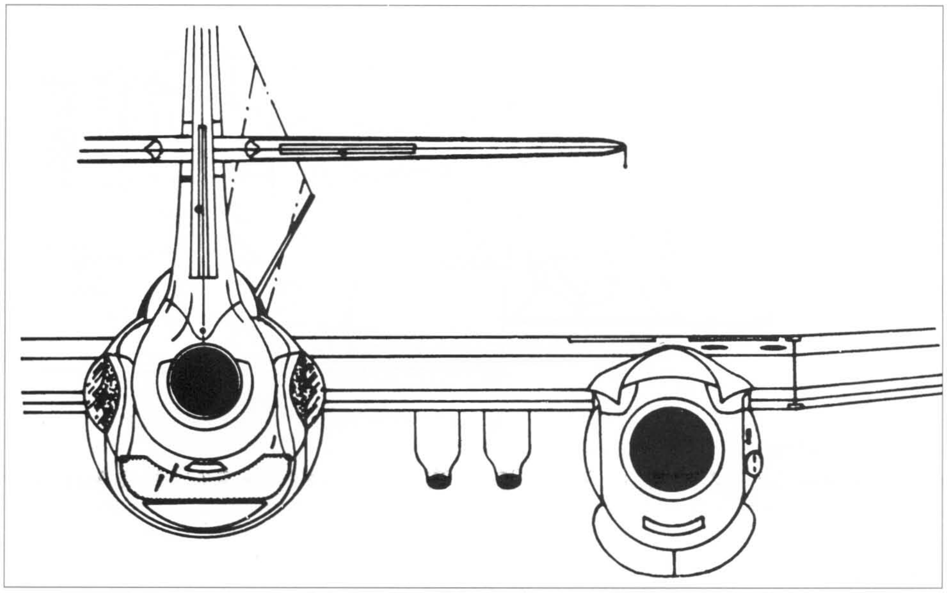
Type: Four-seat tactical bomber. The airframe was of all-metal construction.

Fuselage. The semi-monocoque fuselage with a thick stressed skin featured a structure in which stringers and frames were the main elements of the framework.

The crew was accommodated in two pressure cabins; in the event of an emergency the crew baled out through hatches in the lower part of the pressurised cabins. The hatchcovers were forward-hinged, doubling as slipstream deflectors to protect the crew. The navigator, gunner/radio operator and pilot escaped through the forward hatch, the gunner in the cabin amidships escaped through the rear hatch. If the aircraft became uncontrollable, the pilot could jettison a part of the canopy and make use of the ejection seat.



The rear fuselage of the '73' bomber, showing the air intake of the auxiliary engine closed by a movable fairing. The hatched line shows an alternative configuration with a non-closeable circular intake.



Above: Rear view of the '73', showing the twin JATO bottles mounted under the inner wings.

Below: The second prototype of the '73' (Tu-14) featured the intended dorsal and ventral cannon barbettes but no forward-firing cannons.

The aircraft's armour was intended to protect the crew from behind against 20-mm (.78 calibre) armour-piercing shells. The weight of the armour plating totalled more than 300 kg (660 lb). From beneath the crew was protected from anti-aircraft shell fragments by an 8-mm (0.31 in) duralumin skin panel forming an integral part of the structure.

Wings: Cantilever shoulder-mounted monoplane wings built in three sections, with zero dihedral on the inner wings and marked dihedral on the outer wings.

The wings were a three-spar structure featuring high-speed TsAGI airfoils with a thickness/chord ratio of 12% (the P-11-2 on the wing centre section and the P-11-1 on the outer wing panels). The space between the No.1 and No.2 spars was a torsion box with a thick skin reinforced by internal corrugated stiffeners which were oriented spanwise. The skin between the No.2 and No.3 spars was thinner; it was reinforced with transverse corrugated stiffeners.

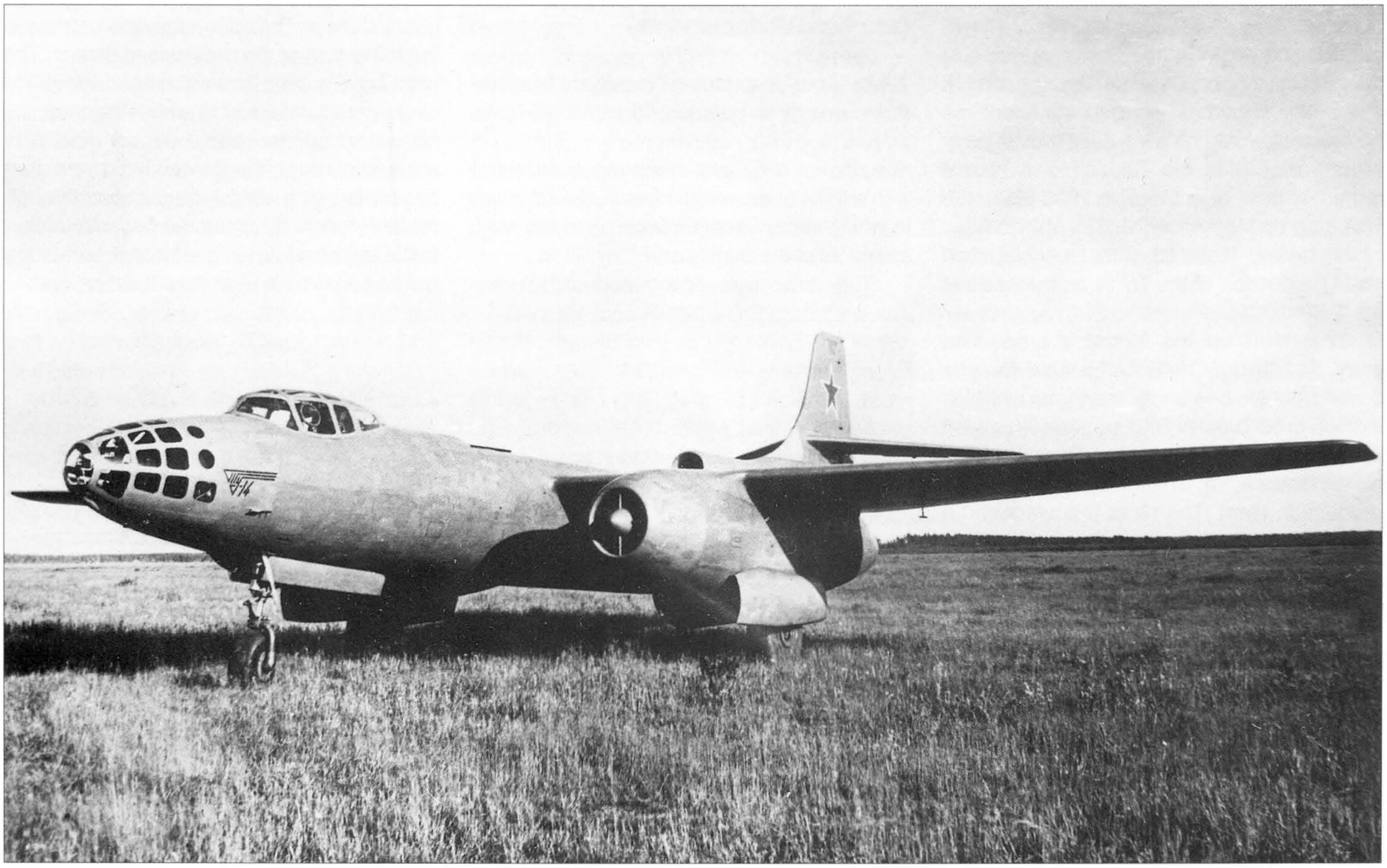
The wings featured hydraulically actuated Schrenck flaps, with ailerons outboard of these; the ailerons had 35% aerodynamic balancing.

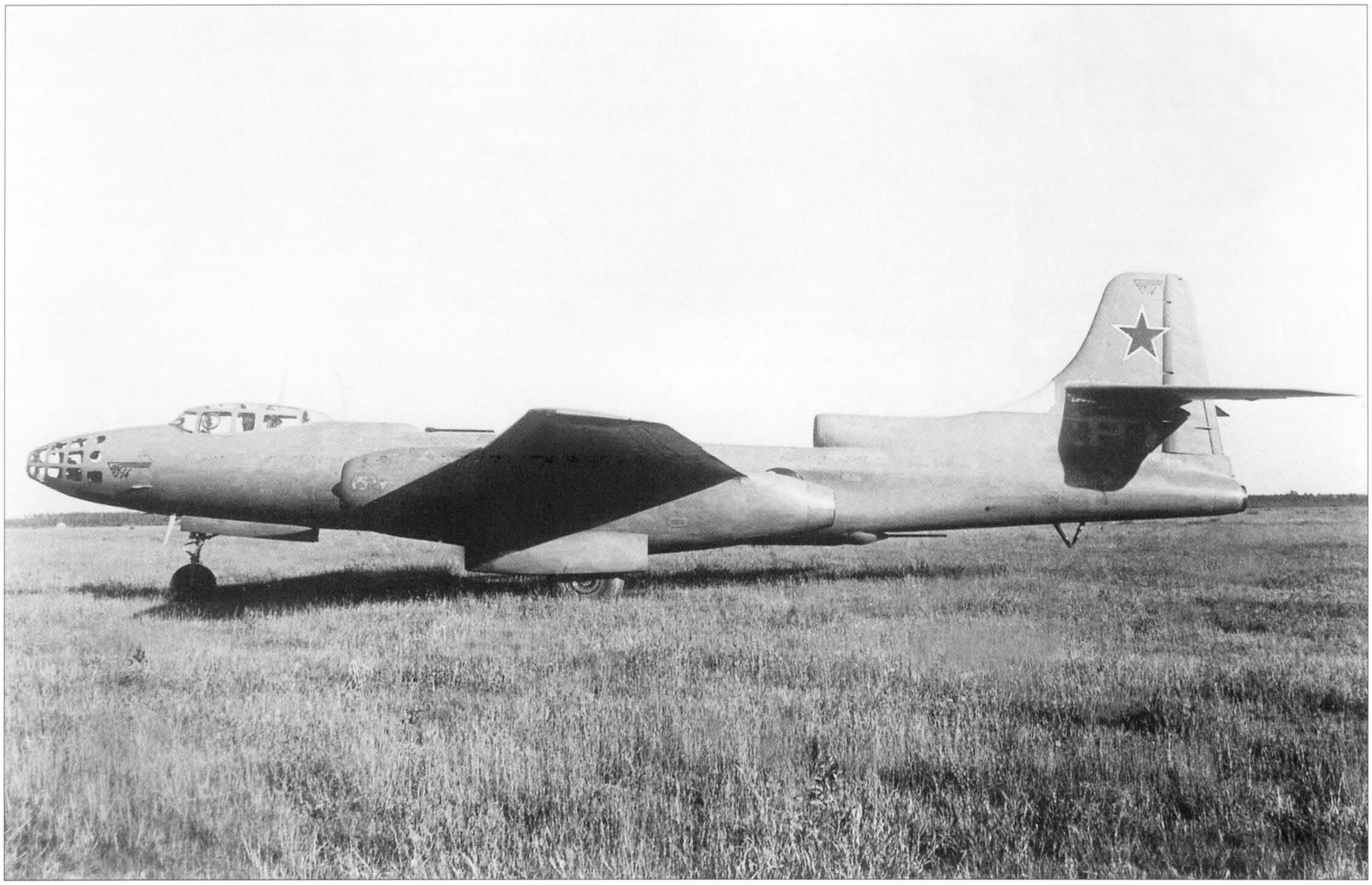
Tail unit: Cruciform cantilever tail surfaces. The trapezoidal fin had a very wide chord at the root, blending into a thick root fillet which was used for accommodating the air intake of the rear engine.

The horizontal tail was swept. All control surfaces had metal skinning; the elevators were provided with trim tabs.

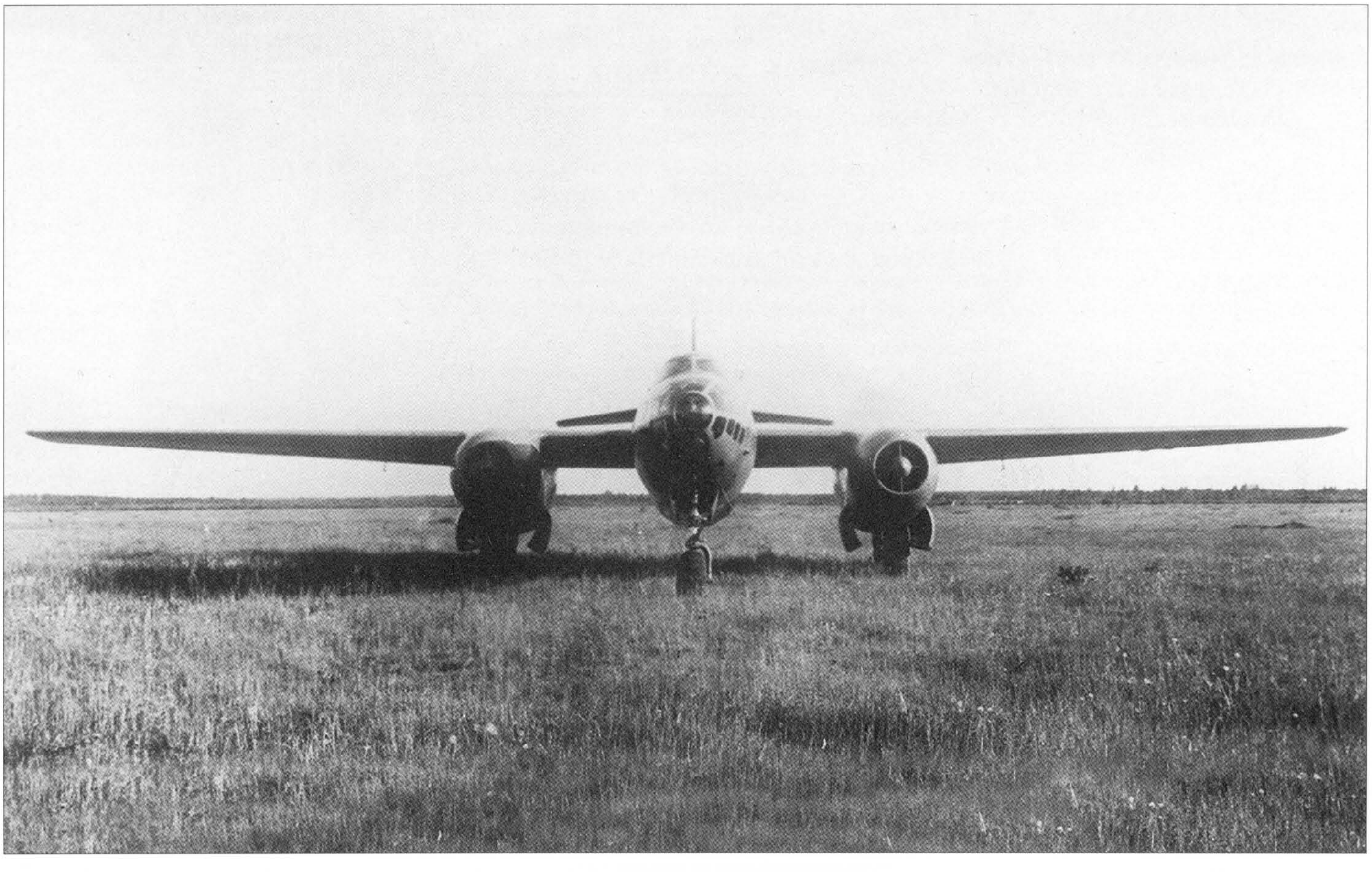
Landing gear: Hydraulically retractable tricycle type, with pneumatic emergency extension; all units had single wheels and oleo-pneumatic shock absorbers. The aft-retracting steerable nose unit had a hydraulic shimmy damper similar to the type used on the North American B-25 Mitchell.

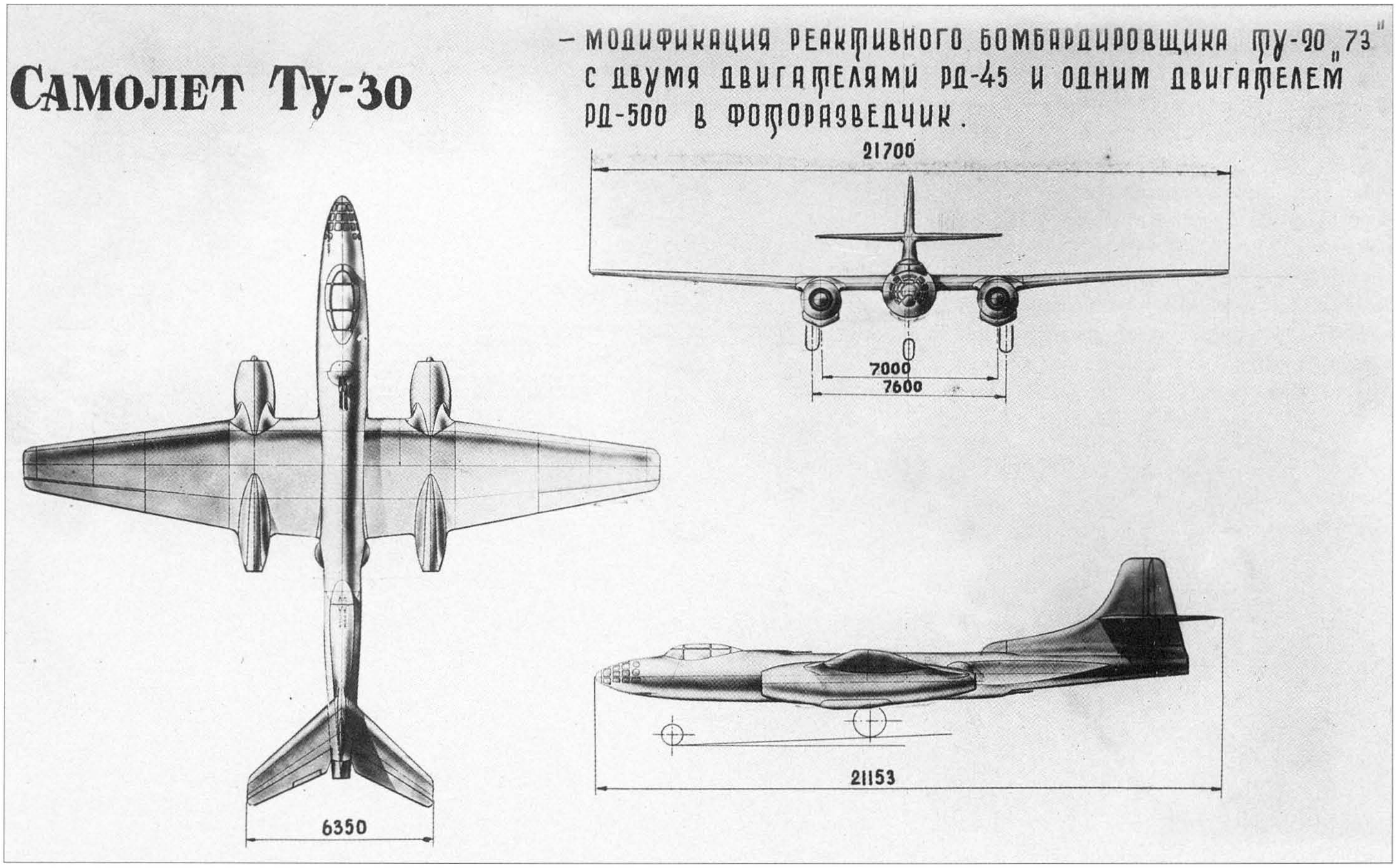
The main units had 1,150 x 310 mm (45.27 x 12.20 in) wheels with high-pressure tyres permitting take-off with an AUW of up to 22 tonnes (48,510 lb). The main gear units retracted forward into the engine nacelles, the wheels rotating through 90° by means of mechanical linkages.



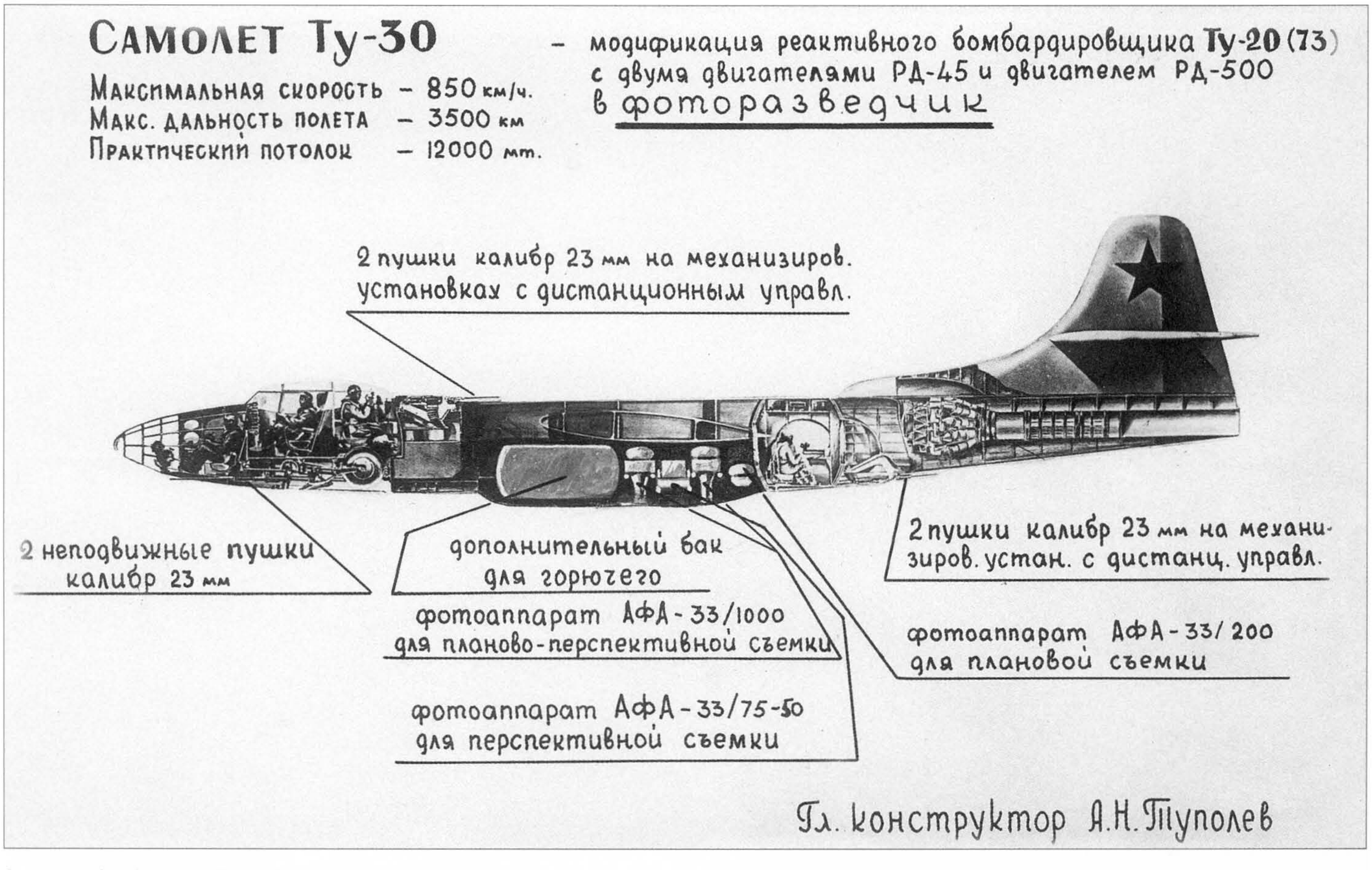


Above and below: The second prototype ‘73’ (Tu-14) seen during State acceptance trials. This aircraft differed from the first prototype in having a circular-section non-closeable centre engine air intake of increased area. Note the ‘Tu-14’ nose titles.




Самолет Ту-30
– модификация реактивного бомбардировщика Ту-20 „73"
с двумя двигателями РД-45 и одним двигателем
РД-500 в фоторазведчик.
21700
7000
7600
21153
6350

Above: The Tu-20R soon evolved into a different photo reconnaissance version with two RD-45s and one RD-500 designated '78' and allocated the provisional service designation Tu-30.


Самолет Ту-30
– модификация реактивного бомбардировщика Ту-20 (73)
с двумя двигателями РД-45 и двигателем РД-500
в фоторазведчик
Максимальная скорость – 850 км/ч.
Макс. дальность полета – 3500 км
Практический потолок – 12000 мт.
2 пушки калибр 23 мм на механизиров.
установках с дистанционным управл.
2 неподвижные пушки
калибр 23 мм
дополнительный бак
для горючего
фотоаппарат АФА-33/1000
для планово-перспективной съемки
фотоаппарат АФА-33/75-50
для перспективной съемки
2 пушки калибр 23 мм на механизиров. устан. с дистанц. управл.
фотоаппарат АФА-33/200
для плановой съемки
Гл. конструктор А.Н. Туполев

A cutaway drawing of the Tu-30 ('78'), showing the different configuration of the camera bay. The long-range fuel tank was located ahead of the cameras – two AFA-33/1000 cameras on tilting mounts, with an AFA-33/75-50 oblique camera in between and an AFA-33/200 vertical camera further aft.

Powerplant: Two Rolls-Royce Nene I centrifugal-flow turbojets rated at 2,000 kg (4,410 lb) at sea level installed under the wings in area-ruled nacelles adhering directly to the wing undersurface, plus one Rolls-Royce Derwent V centrifugal-flow turbojet rating of 1,640 kg (3,616 lb) at sea level was installed in the rear fuselage.

Since the third engine was used mainly during take-off and climb and in the maximum speed flight mode, while in cruise flight it was switched off, the inlet section of the air intake pivoted around a horizontal axis and closed the inlet with a special fairing. When the engine was running, the fairing was retracted into the fuselage.

Control system: Mechanical controls with rigid push-pull rods and bellcranks. The control system incorporated reversible hydraulic actuators which reduced the control forces by a factor of 3 to 9. The trim tabs were electrically controlled.

Fuel system: The fuel was carried in 22 bag-type tanks in the wings and the fuselage. The total capacity of the fuel system was 10,000 litres (2,200 Imp gal) or 8,000 kg (17,640 lb). The tanks were divided into two main and two auxiliary groups (port and starboard) to serve the port and starboard engine respectively. The centre engine was fed from both groups of tanks.

Electric system: On the '73' aircraft powered by Nene and Derwent engines, DC power was supplied by British-manufactured 1.5-kW generators, one on each main engine. This was clearly insufficient, and installation of 6- to 9-kW generators was envisaged after switching to the intended RD-45 cruise engines of the production version. Two 12A-30 storage batteries served as a back-up DC power source.

The aircraft was equipped with lights in a fashion similar to the Tu-4. Two retractable FSV-200 landing lights were used for night landings.

Air conditioning and pressurisation system: On the first prototypes (including the '73' aircraft) the air supplied to the pressurised cabins was to be bled from the compressors of the Nene-1 engines; on production machines it was to be fed by cabin superchargers installed on the accessory drive gear boxes. Turbine refrigerators were to be provided for cooling the air.

Pressure in the cabins was maintained by automatic regulators. For high-altitude flights under combat conditions each crew work station was equipped with an oxygen breathing apparatus for use in the event of depressurisation. The oxygen supply was sufficient for a flight of two hours' duration.

Bomb load options for the '73' bomber

Bomb calibre, kg (lb)	3,000 (6,610)	1,500 (3,310)	500 (1,102)	250 (551)	100 (220)
Number	1	1	4	8	12
Total weight of bombs, kg (lb)	3,000 (6,615)	1,500 (3,307)	2,000 (4,410)	2,000 (4,410)	1,200 (2,646)

Armament: The *offensive armament* options of the '73' aircraft are given in the table above. FAB-3000 M-46, FAB-1500 M-46, FAB-500 M-44, FAB-250TsK and FAB-100TsK bombs were used. The bombs were carried inside the bomb bay on detachable and fixed bomb racks. An electric release system was used. Bombing precision was achieved with the help of the OPB-4S optical sight connected with the autopilot.

The *defensive armament* consisted of six 23-mm (.90 calibre) Nudelman/Rikhter NR-23 cannons. Two of these were fixed forward-firing cannons with 85-100 rpg; they were fired by the pilot who aimed them by means of a PK-I collimating sight. Protection of the rear hemisphere was provided by two hydraulically actuated remote-controlled twin-cannon barbettes (dorsal and ventral). Each barbette had its own power supply unit, an electrically driven hydraulic pump and a hydraulic accumulator. Optical sights were used for aiming. To improve visibility for the gunner of the ventral installation, recesses were provided in the fuselage sides aft of the lateral sighting blisters. The ammunition complement of the barbettes was 250 rpg. The chosen defensive armament, as regards its calibre and ballistics, ensured adequate protection at distances up to 1,000 m (3,280 ft) and was intended to fend off attacks by fighters armed with 37-mm (1.19 calibre) cannons.

Avionics and equipment:
Piloting and navigation equipment: To ensure the ability to operate in any weather in the daytime and at night, in addition to the standard complement of navigation devices, the aircraft was fitted with a DIK-46 flux-gate compass, an AB-52 drift sight, an ARK-4 automatic direction finder, an RV-2 radio altimeter for low altitudes, a Litiy (Lithium) radio altimeter for high altitudes, an SP-50 Materik instrument landing system/short-range radio navigation system (SHORAN) and a marker beacon receiver to indicate the passing of the airfield boundary. Provision was made for the installation of the NK-46 ground position indicator and the Meridian long-range guidance system (LORAN).

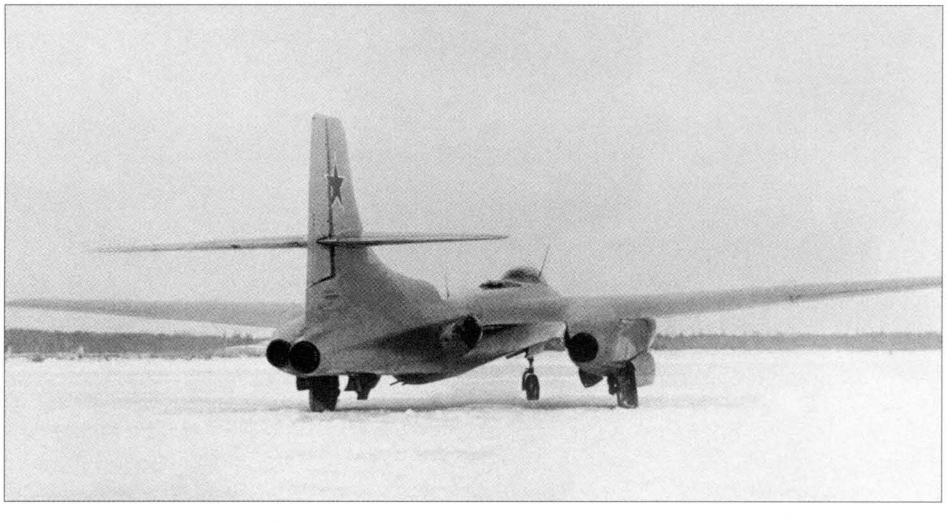
To reduce the pilot's workload and increase bombing accuracy, the aircraft was equipped with an AP-5 autopilot with a link from the directional control channel to the OPB-4S optical bomb sight.

Communications equipment: Air-to-air and air-to-ground communications were effected with the help of an 12RSU Kura (the name of a river) radio and an RSB-3*bis* AD radio; in production it was to be replaced by the RSB-5 radio. An SPU-5 intercom was fitted.

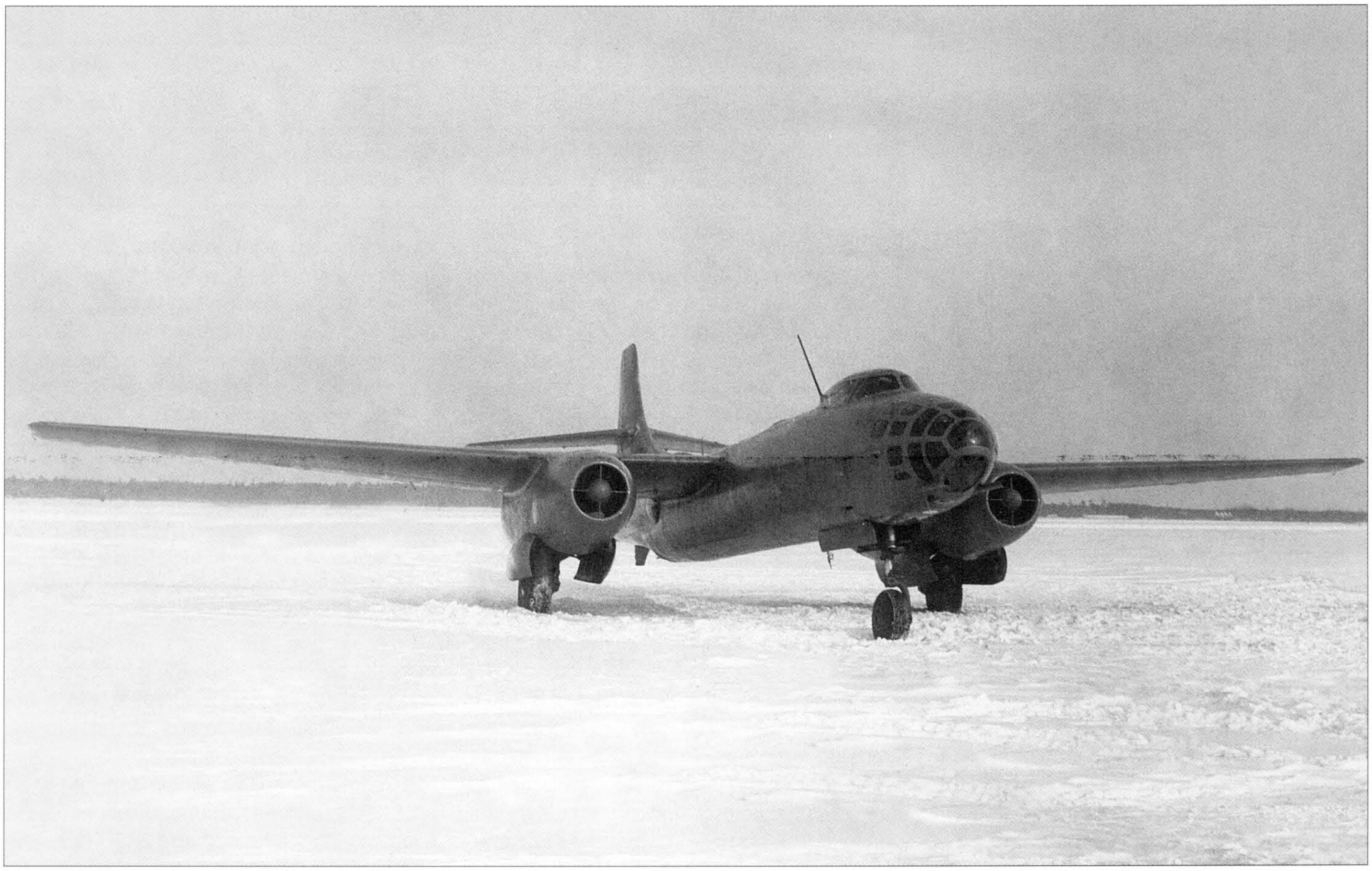
Radar equipment: The aircraft was equipped with a Ton-3 radar warning receiver alerting the crew that the aircraft was being painted by enemy radar.

IFF equipment: Bariy IFF transponder.

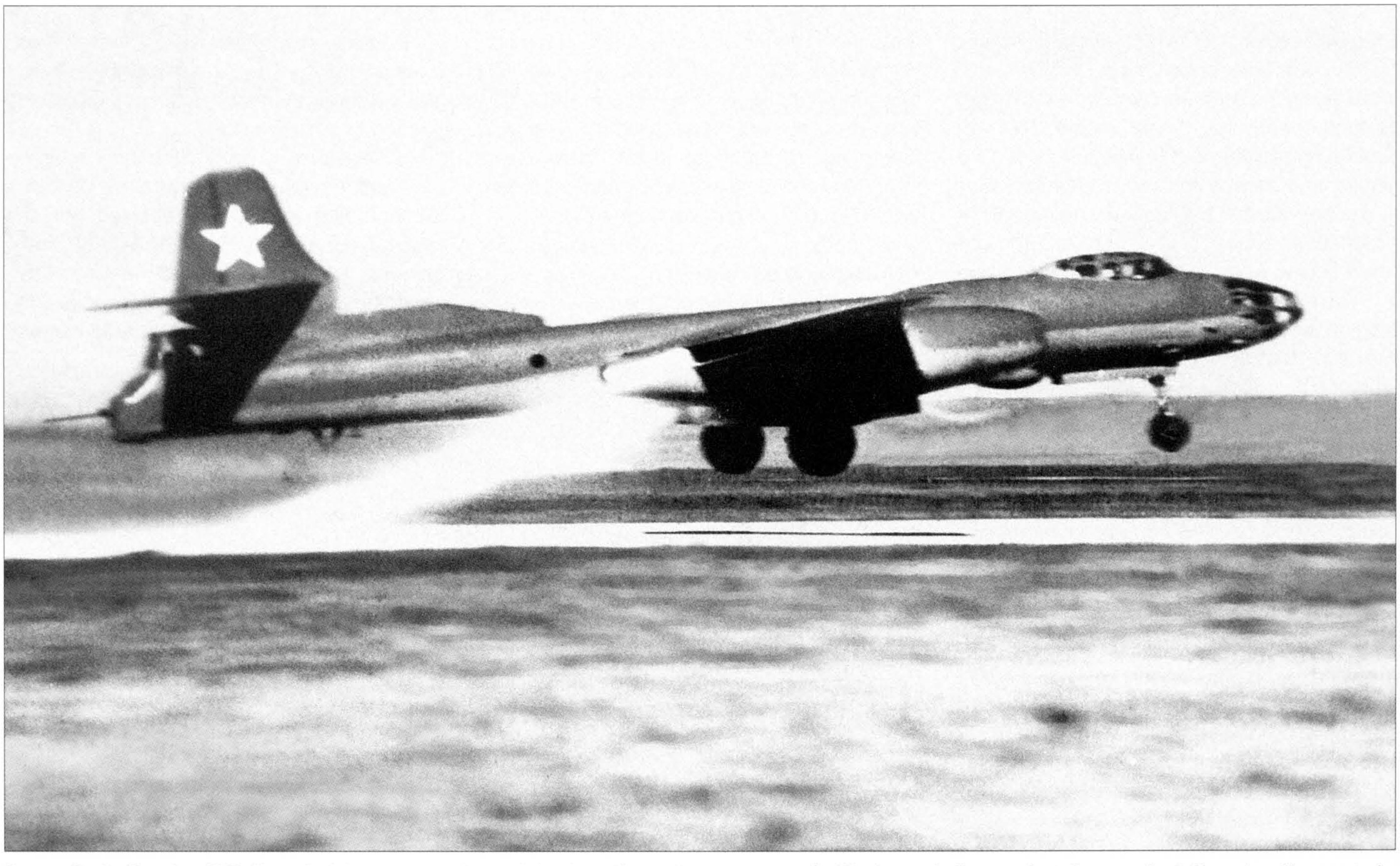
Photo equipment: Photographic control of the bombing results was effected with the help of an AFA-33/75 or AFA-33/50 aerial camera. The camera could be tilted rearwards to an angle of 45°. For night sorties the AFA-33 was replaced by an NAFA-3S camera.



The actual prototype of the '78' reconnaissance aircraft lacked the ventral fairing over the camera bay apparent on the project drawings. Note how a cutout in the rudder fits around the stabiliser trailing edge.



Above: Another aspect of the '78' prototype during manufacturer's flight tests. Note the two forward-firing cannons in the nose.



Eventually the Tupolev OKB discarded the centre engine and the dorsal/ventral remote-controlled barbettes in favour of a tail gunner's station when the uprated VK-1 engines became available. Here a production Tu-14 bomber blasts off with the help of JATO rockets.

Chapter 8

IL-28: Soviet Canberra

The IL-28 well and truly deserves a separate monograph. Being the sole Ilyushin bomber to achieve production and service, it 'compensated' by being an eminently successful design, and it was to the Eastern Bloc what the English Electric Canberra was to the West. For reasons of space, only the type's development history can be outlined here.

The IL-28 project was conceived in late 1947. On 31st October that year Sergey V. Ilyushin wrote to Minister of Defence Nikolay A. Bulganin, proposing a tactical bomber powered by two Rolls-Royce Nene I turbojets, with a first flight date tentatively set for July 1948. This tight schedule was due in no small part to the experience gained with the IL-22, which would allow the new bomber to be developed quickly. The objective was to achieve a performance far superior to that of the IL-22 and the projected IL-24. This was made possible by reducing the crew and rethinking the defensive armament concept.

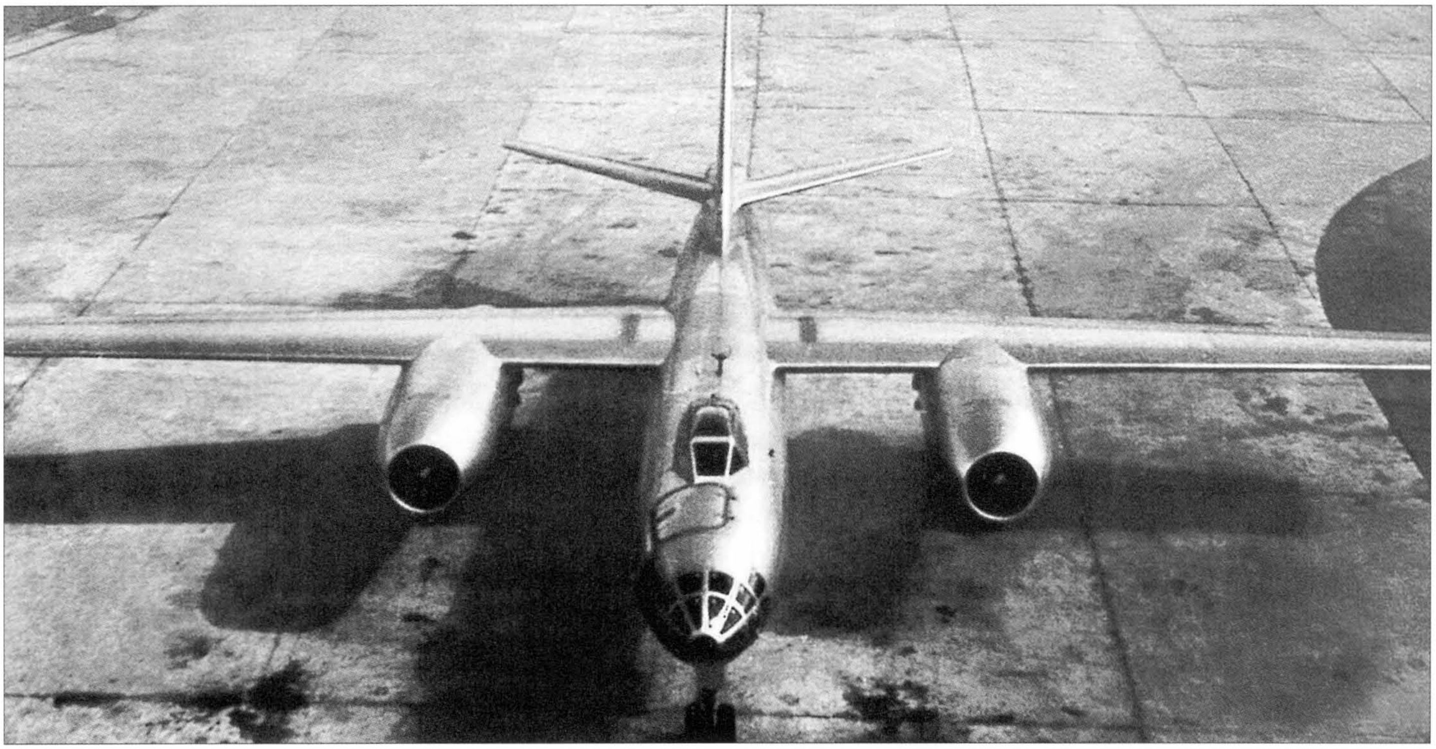
Being similar to the predecessor in layout, the IL-28 was rather smaller and differed in a number of important respects. This was due to the new bomber's higher speed and different service conditions – unlike the IL-22, the IL-28 was designed to operate mainly from tactical airfields with unpaved strips.

The crew was reduced to three – pilot, navigator/bomb aimer and tail gunner/radio operator. The decision to eliminate the co-pilot and forward gunner was dictated first of all by the limited mission time of a tactical bomber. At a cruising speed of 650-750 km/h (403-434 mph) a sortie would typically last 2 or 2½ hours – 4 hours at the most. An autopilot would be installed to ease the pilot workload during cruise.

The armament would probably best be described here, as the IL-28 was, as one Russian writer put it, 'designed around the tail' – or, to be precise, the tail turret. Trials of the IL-22 had shown serious deficiencies as described in Chapter 2, which needed to be eliminated. Various armament arrangements were studied. Eventually the engineers decided that a single tail turret offered adequate protection against fighter attacks from the rear hemisphere, providing the cannons' traversing/elevating angle and speed were increased and the bomber made appropriate defensive manoeuvres. Besides, the use of only a single tail turret reduced empty weight and improved aerodynamic efficiency.

Yet designing a new tail turret turned out to be quite a challenge; the engineers had to meet stringent specifications while keeping the unit's weight to a minimum. The IL-KU3 tail turret turned out to be too sluggish; a new power drive and remote control system had to be developed. The result was the highly efficient IL-K6 turret, originally mounting the same NS-23 cannons (later replaced by Nudelman/Rikhter NR-23s) with 225 rpg. The new weapons had the same calibre but a much higher rate of fire – 850 rounds per minute versus 550 rpm for the earlier model.

The IL-K6 electrohydraulically-powered remote-controlled turret had a traversing angle of ±70° and an elevating angle of +60°/–40°. In normal mode the cannons moved at a rate of 15-17° per second, the motion increasing to up to 36° per second in boost (emergency) mode. The power drive enabled the turret to operate adequately at airspeeds in excess of 1,000 km/h (555 kts). At 340 kg (750 lb), the turret was relatively



The first prototype of the IL-28 was powered by Rolls-Royce Nene I engines and did not yet have area-ruled engine nacelles.

lightweight. By comparison, the DK-3 turret used on the Tu-4 bomber had traversing and elevating angles of only ±30° while weighing nearly 390 kg (860 lb).

The power drive of the IL-K6 turret was built around an unusual swivelling hydraulic pump unit driven by two 5-kW electric motors. The output of the pumps and hence the motion speed of the cannons depended on the angle at which the pump unit was tilted; with the pump unit in a neutral position the turret remained motionless. This made it possible to dispense with slide valves, reservoirs and other unreliable components, resulting in a simple and safe hydraulic system. The ammunition boxes were built into the body of the turret, allowing the customary belt feed and tightening mechanisms to be dispensed with, which again made for higher reliability.

The turret was electrically controlled by means of a highly reliable and precise potentiometric tracking system. Targeting was done by a computing gunsight which automatically made adjustments for the target's motion, shell velocity and trajectory, cannon traversing angle, flight altitude and airspeed. The sight received feedback from the turret to minimise miscoordination between the two. Thus, miscoordination in the horizontal plane was three times less than the limit set by general operational requirements of the time.

The IL-28 also featured two fixed forward-firing NR-23 cannons with 100 rpg installed on both sides of the nose on quick-release mounts. These were fired by the pilot and could be removed by simply disconnecting an electrical connector and turning a locking lever.

The decision to use only a single power turret and reduce the crew to three enabled the designers to make the IL-28's fuselage nearly 3.5 m (11 ft 5¾ in) shorter than that of the IL-22 and reduce wing area by 13.7 m^2 (147.3 sq ft), which led to a significant reduction in empty weight. Hence the second major difference was the powerplant. The basic projected size and weight allowed the new bomber to be powered by two Rolls-Royce Nenes rated at 2,270 kgp (5,000 l st).

The Nene, which entered licence production in the USSR in 1947 as the Klimov RD-45, had by then reached a high degree of reliability and boasted a 25-30% lower specific fuel consumption as compared to the Lyul'ka TR-1. On the other hand, a major drawback of this engine was its large diameter caused by the centrifugal compressor. This, and the necessity to keep the air intakes as far away from the ground as possible in order to avoid foreign-object damage (FOD) – a must since the aircraft was to operate from dirt airstrips – led the designers to mount the engines in nacelles adhering directly to the lower surface of the wings (ie, without pylons).

For CG reasons the engines were located well forward in the nacelles. Thus, the large diameter of the engine's compressor and the small jetpipe allowed the main gear units to be relocated from the fuselage to the engine nacelles, giving a wide track which was a bonus on semi-prepared strips. The shock struts were attached to the nacelles' main frames, and as they retracted forward the single mainwheels turned through 90° by means of a simple mechanical link to lie flat in the bottom of the nacelles beneath the extension jetpipe. Incidentally, here the Ilyushin OKB made a virtue out of necessity: the landing gear struts were noticeably longer than the IL-22's, giving a large ground clearance under the fuselage and easing the bomb loading procedure. In contrast, the IL-22 had a very small ground clearance, needing to be jacked up when 2,500-kg (5,510-lb) and 3,000-kg bombs were hooked up.

To meet the high speed requirement the IL-28's wings employed a new TsAGI SR-5S high-speed airfoil developed under the guidance of Yakov M. Serebriyskiy and Maria V. Ryzhova – again with a 12% thickness/chord ratio. This enabled the bomber to reach a maximum speed of Mach 0.82 at 7,000-8,000 m (22,965-26,250 ft) without any adverse effects on stability and handling caused by shock wave formation. The provision of simple slotted flaps assured the IL-28 good field performance.

The high design speeds called for a swept tail unit which ensured good stability and handling throughout the speed range. The tail unit employed symmetrical airfoils with a slightly higher thickness/chord ratio than that of the IL-22. The fin was swept back 41° at quarter-chord while the stabilisers were swept back 30°; this delayed dangerous Mach buffeting to a speed well above the aircraft's never-exceed speed. In addition, the sweepback increased the rudder and elevator arm, which allowed the area and weight of the tail surfaces to be reduced.

One of the complaints voiced by the IL-22's pilots during flight tests concerned the flightdeck glazing which was blended entirely into the nose contours. The curved glazing panels distorted the view and generated annoying reflections, and the heavy framework created numerous 'blind spots'. Since the IL-28 would be flown by a single pilot, the engineers provided him with a fighter-type cockpit enclosed by a sideways-opening bubble canopy with a bulletproof windscreen. The extensive nose glazing was still there of necessity, but now the navigator/bomb-aimer had the glazed nose all to himself.

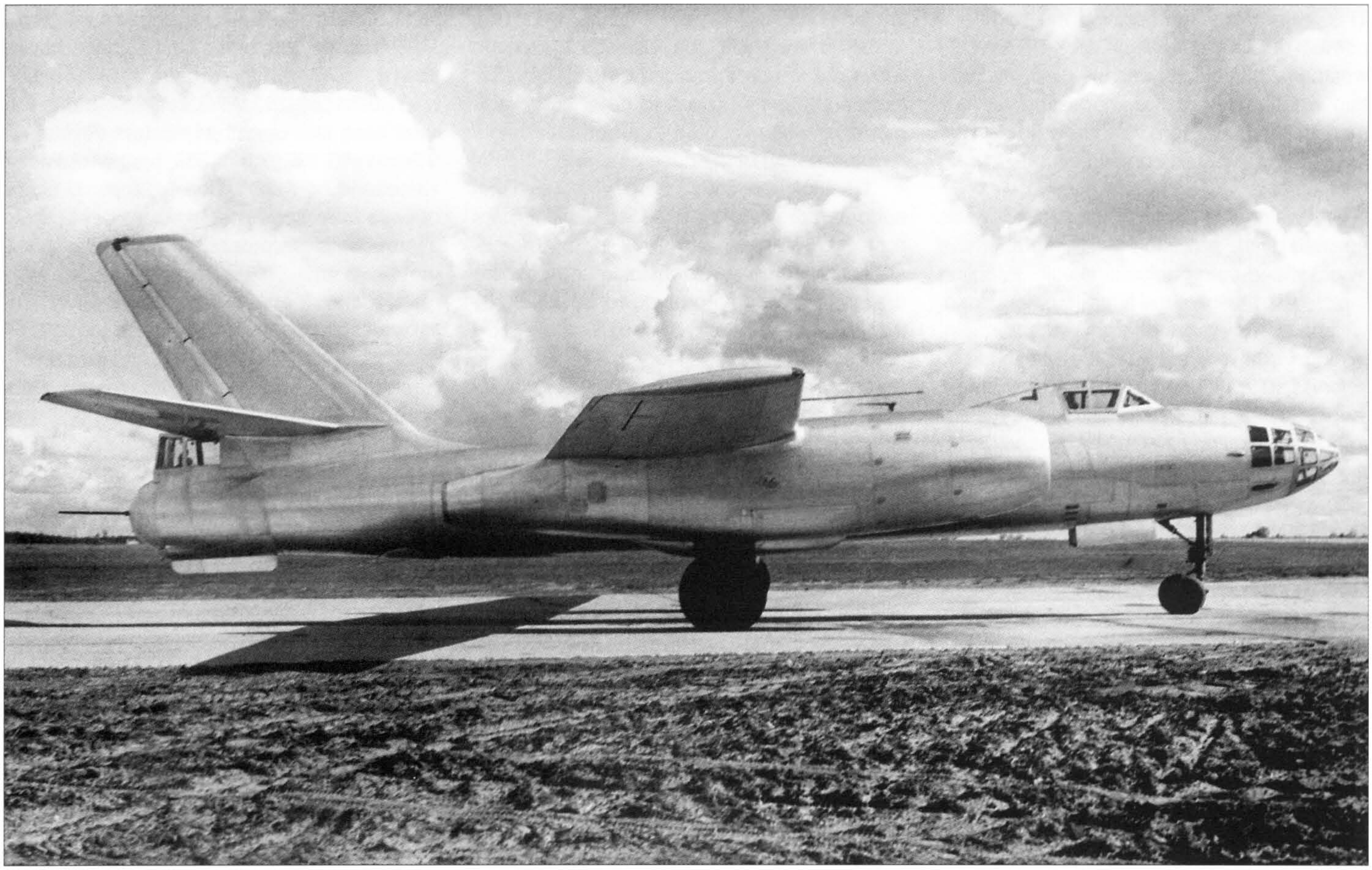
The crew was seated in two pressurised compartments – one for the pilot and navigator/bomb-aimer, the other for the gunner/radio operator. At low altitudes these were pressurised by the slipstream; from 1,700 m (5,580 ft) and up the compartments were sealed off and pressurised by engine bleed air via filters. The pressurisation system was combined with the heating and ventilation systems. The cockpit and navigator's compartment were equipped with upward-firing ejection seats; ejection was triggered by jettisoning the canopy or entrance hatch respectively. The gunner bailed out via the ventral entrance hatch; the hatch cover doubled as a shield protecting him from the slipstream.

As had been the case with the IL-22, the IL-28's wing panels and tail surfaces had a manufacturing joint running along the chord line. Each half of the unit consisted of a number of panels incorporating stringers and ribs. This allowed different panels to be manufactured simultaneously at different workstations while improving working conditions; noisy and labour-intensive manual riveting was replaced with high-quality machine riveting.

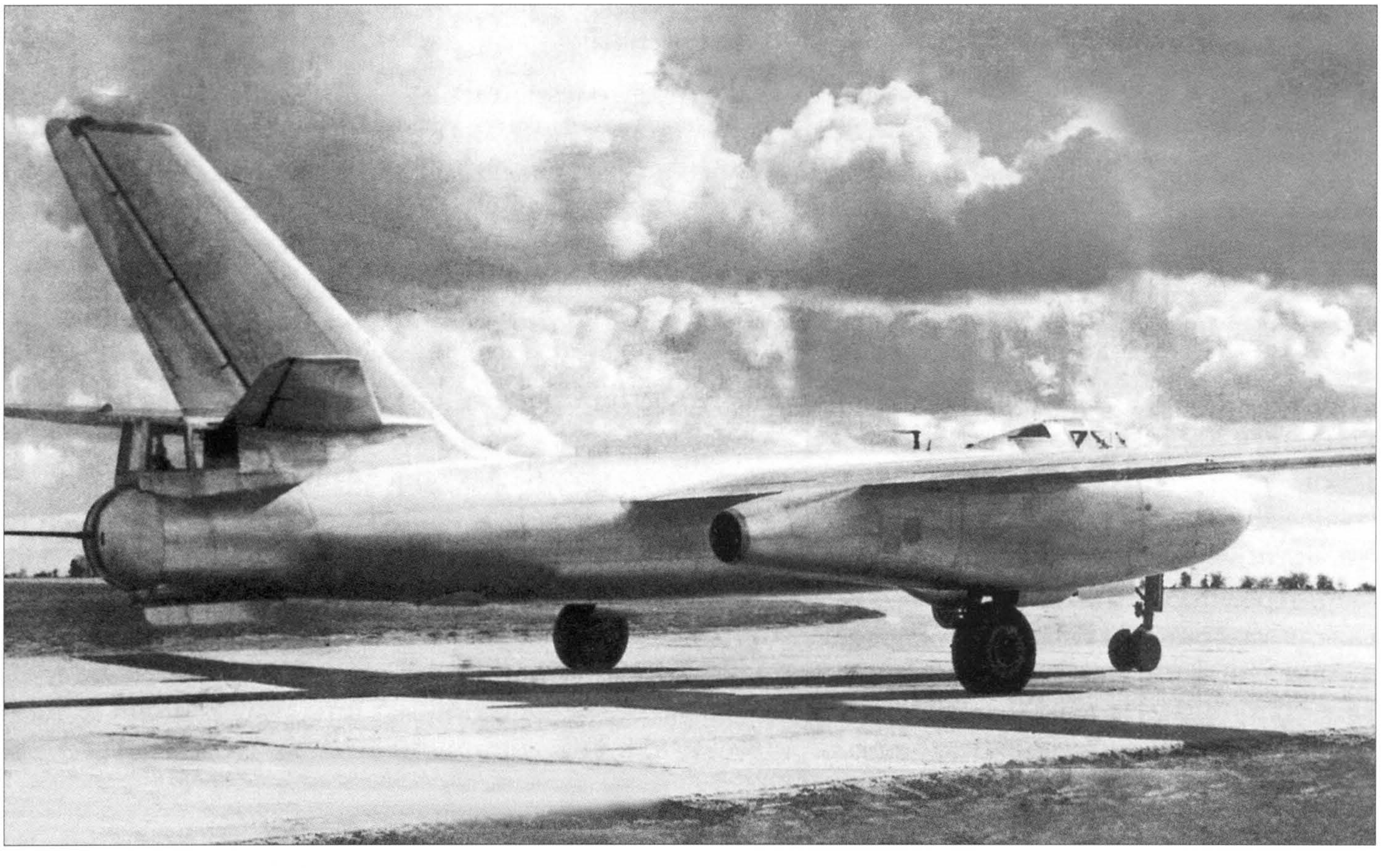
The fuselage was also designed in two halves with a manufacturing joint running the full length of it. For the first time in Soviet aircraft mass production, all structural members of the fuselage were readily accessible, allowing riveting and assembly operations to be mechanised and various internal equipment to be fitted quickly and efficiently. The fuselage was also divided into four sections, facilitating the installation of equipment in bays which would not be accessible once the structure was fully assembled. Finally, the fuselage had longitudinal recesses on both sides covered by removable skin panels. These facilitated installation of all wiring and pipelines during manufacturing, as well as checking them and replacing faulty components in service. This feature reduced preflight check time and enhanced combat efficiency.

The slight weight penalty (about 4%) incurred by the new technology more than paid off. The surface finish was significantly improved; labour intensity was cut by 25-30% for production airframes and by 30-40% for internal equipment installation. As a result, the twinjet bomber was hardly more complicated to build than a tactical fighter. Also, this allowed Ilyushin to avoid the aforementioned *val'ozhka* (uncommanded bank) problem which affected some early Soviet jets.

The Ilyushin OKB had accumulated a lot of design and operational experience with hot air de-icing systems and put it to good use when working on the IL-28. The turbojet engines powering the aircraft supplied lots of bleed air and enabled the engineers to quickly create the most efficient de-icing system of the time. This was the Soviet Union's first automatic hot air de-icing system; it was lightweight, reliable and simple to operate and had no parts disrupting the airflow.



Above and below: Two more views of the first prototype IL-28 during manufacturer's tests; note the closed mainwheel wells and retracted radome of the PSBN-M radar under the rear fuselage. Apart from the powerplant and the engine nacelle design, production IL-28s differed in having a simpler cockpit canopy frame, a revised nose glazing, a repositioned radar in a teardrop-shaped radome aft of the nose gear and no strake under the tail gunner's station.



This feature greatly improved the bomber's combat efficiency and flight safety in adverse weather – particularly because the relatively thin airfoils used in the wings and tail unit made icing much more dangerous than in the case of slower piston-engined aircraft utilising thick airfoils.

All-weather and night flying capability was ensured by the provision of a comprehensive avionics and communications suite enabling the crew to navigate the aircraft, detect, identify and destroy ground targets without maintaining visual contact with the ground. The avionics suite included an OSP-48 instrument landing system for use in instrument meteorological conditions (IMC). The ground part of the system included two range beacons, three marker beacons, communications radios and an HF or VHF radio direction finder to facilitate approach and landing in bad weather. The system's components installed on the aircraft comprised an ARK-5 Amur (a river in the Soviet Far East; pronounced like the French word *amour*) automatic direction finder, an RV-2 Kristall (Crystal) low-altitude radio altimeter and an MRP-48 Dyatel (Woodpecker) marker beacon receiver.

The OSP-48 was fairly simple and had few components, which rendered the ground part suitable for use on *ad hoc* tactical airfields (in truck-mounted form). The aircraft was also equipped with an AP-5 autopilot and an IFF transponder.

Unlike the IL-22, the IL-28's normal bomb load was 1,000 kg (2,205 lb); the maximum bomb load in overload condition remained the same at 3,000 kg (6,610 lb). The bomb bay located in the centre fuselage featured four bomb cassettes and one beam-type bomb cradle. The former could carry bombs of 50-500-kg (110-1,102-lb) calibre while the latter was designed for bombs weighing from 1,000 to 3,000 kg (2,205- 6,610 lb).

In visual meteorological conditions (VMC) the navigator/bomb aimer used an OPB-5S optical bomb sight (*op**ti**cheskiy pr**itsel** bom-bardi**rov**ochnyy*) which enabled him to take aim automatically at stationary and moving targets in level flight. Interestingly, the navigator had to leave his ejection seat and sit sideways on a special jump seat in the extreme nose on the starboard side to use the sight. The OPB-5S computed the sighting angles and dropped the bombs automatically at the proper moment by means of an electric release mechanism. The sight was gyrostabilised to prevent the aircraft's manoeuvres from affecting bombing accuracy and linked to the autopilot, enabling the navigator to set the aircraft's course on its bombing run. In IMC, bomb-aiming was assisted by the PSBN-M search/bomb-aiming radar with a 360° field of view. The radar was located in the aft fuselage just ahead of the gunner's station and enclosed by a dielectric fairing which was retracted flush with the fuselage underside when not in use to reduce drag. (The latter feature evidently proved to be a lemon and the radar was relocated to a non-retractable radome just aft of the nose gear unit.)

General Designer Sergey V. Ilyushin endorsed the IL-28's advanced development project on 12th January 1948, giving the go-ahead to complete a set of manufacturing drawings and start prototype construction. By then, however, Andrey N. Tupolev's OKB-156 – the Soviet Union's leading authority in bomber design – had received an assignment to design and build a similar jet-powered tactical bomber (the '73'). OKB-240 had no such assignment. Still, Ilyushin's belief in his aircraft was so strong that he decided to carry on with the IL-28 and build a prototype at his own risk – all the more so because the Soviet Air Force was in desperate need of a tactical bomber meeting the stringent new requirements. (It is worth noting here that Ghenrikh V. Novozhilov, who succeeded Ilyushin as the OKB's head in 1970, started his career at the Ilyushin OKB by taking part in the preparation of the IL-28 prototype's manufacturing drawings.) The IL-28 was not officially included into the Ministry of Aircraft Industry's experimental aircraft construction plan until 12th June 1948 when the Council of Ministers issued directive No.2052-804 to this effect – one month before the prototype was rolled out.

Bearing no serial or even national insignia, the prototype (powered by authentic Rolls-Royce Nene turbojets imported from the UK) commenced ground tests at Moscow-Khodynka on 29th May 1948. On 1st July the aircraft was dismantled and trucked to the the Ilyushin OKB's flight test facility in Zhukovskiy. V. N. Boogaiskiy was assigned engineer in charge of the flight tests.

The company chief was as good as his word: the bomber took to the air for the first time on 8th July 1948 with Ilyushin OKB chief test pilot Vladimir K. Kokkinaki at the controls; N. D. Sorokin was the flight engineer (*sic* – obviously the navigator) and B. A. Yerofeyev was the radio operator. Kokkinaki was pleased with the aircraft's handling, saying that the IL-28 was easy to fly both during take-off and in cruise and climbed well.

The IL-28 displayed good directional and lateral stability throughout its operational envelope. When properly trimmed the aircraft flew stably in level flight even when the controls were released. Low-speed handling was quite good, with no tendency to stall or spin. Straight and level flight with one dead engine was no problem either, the yaw being easily countered without excessive loads on the rudder pedals.

The aircraft had good field performance and could operate from existing airbases and tactical airfields. At a normal gross weight of 17,220 kg (37,960 lb) the take-off run was just 560 m (1,840 ft) if the aircraft was fitted with two PSR-1500-15 JATO rockets under the inner wing sections; the boosters developed a thrust of 1,600 kgp (3,530 lb st) each with a 13-second burn time. The IL-28 could easily operate from dirt strips; in fact, the test pilots expressly recommended operating the bomber from dirt strips in order to prolong the tyres' service life, which initially left something to be desired.

During manufacturer's flight tests the Nene-powered first prototype attained a top speed of 833 km/h (517 mph) at 5,000 m (16,400 ft) and reached Mach 0.79 at 7,000-8,000 m (22,970-26,250 ft). The test pilots reported that the aircraft behaved normally at these speeds and could go even faster if appropriate changes were made. Hence the OKB set about streamlining the airframe and installing more powerful engines.

The Tupolev OKB's '73' trijet bomber prototype and its '78' reconnaissance derivative were undergoing manufacturer's flight tests at the same time. One day General Designer Andrey N. Tupolev saw the IL-28 prototype at the LII airfield. Being, by many accounts, an ill-tempered person and a man who did not care about competition (to say the least), Tupolev was openly scornful at first. 'Humph! Whose bastard child is this?' he asked the technicians working on the aircraft. However, after examining the competitor's product closely and studying the specifications he had a long talk with his aides, and it was easy to see that he was very displeased. The reason for Tupolev's displeasure was obvious: on their jet bombers the Tupolev engineers had copied the defensive weapons arrangement of the piston-engined Tu-2, which led to overly large dimensions, an excessively large crew and hence excessive weight, not to mention the decidedly complex powerplant. The ultimate '81' (Tu-14) tactical bomber and '89' (Tu-14T) torpedo-bomber dispensed with the centre engine and the two remote-controlled gun barbettes in favour of a single tail gunner's station – inspired by the IL-28, no doubt.

On 30th December 1948 the second prototype IL-28 powered by production RD-45F engines entered flight test, again flown by Vladimir Kokkinaki. New models of tyres were tested concurrently with the aircraft itself, as the original ones were totally worn out after just ten landings on concrete strips. The best results were attained with tyres made of perlone, a synthetic rubber recently put into production by the Soviet chemical industry, which lasted for more than 100 landings.

Apart from the powerplant, the second prototype differed from future production IL-28s in avionics and equipment fit. The aircraft was equipped with RSB-5 and RSU-10 radios, an SPUF-3 intercom, an MRP-46 marker beacon receiver, AFA-BA and AFA-33/50 or AFA-33/75 aerial cameras, two GSN-3000 generators, three sets of KP-14 breathing apparatus with 8-litre (1.76 Imp gal) liquid oxygen bottles, an RUSP-48 ILS etc.

After the successful completion of the initial flight test programme the second prototype was turned over to the Soviet Air Force Research Institute (NII VVS – Naoochno-issledovatel'skiy institoot voyenno-vozdooshnykh seel) for State acceptance trials which lasted from February to April 1949. The formal Act of acceptance was signed on 18th May.

The specifications of the RD-45F-powered second prototype IL-28 attained at the State acceptance trials are detailed in Table 1.

Table 2 gives a performance comparison of the IL-28 and Tu-14. Note that the figures stated for the IL-28 differ from those in Table 1; however, in both cases they originate from official documents. A possible explanation is that different examples of the IL-28 were involved – or that whoever prepared the comparative table was not very honest, 'doctoring' the figures to benefit the IL-28.

The Tu-14 was being tested concurrently; the Powers That Be were to choose between the two, so that in effect Ilyushin and Tupolev had a fly-off, even though the term was unknown in the Soviet Union at the time. Hence the Air Force top brass was in a turmoil; some of the generals and marshals lobbied for the Tu-14 which had somewhat longer range, while other supported the IL-28 which was much easier to build and operate. The discussion raged on at the ministerial level; the chief of GK NII VVS denounced the IL-28 and strongly urged the Minister of Defence Nikolay A. Bulganin to give the go-ahead for the Tu-14. Still, even Bulganin failed to resolve the issue.

Finally, on 14th May 1949 a special commission chaired by Iosif V. Stalin himself analysed the test results and compared the performance of the two types. According to Ilyushin, after examining the reports carefully and listening to his military advisors Stalin picked the IL-28. However, Ilyushin was requested to increase the speed of production aircraft pronto to 900 km/h (486 kts) by re-engining the IL-28 with more powerful and fuel-efficient Klimov VK-1 turbojets; Council of Ministers directive No.1890-700 to this effect appeared that same day. (Makes you wonder if the pro-Ilyushin lobby had prepared the directive in advance, foreseeing this victory!) The VK-1 was a version of the RD-45F uprated to 2,700 kgp (5,950 lb st). As a 'consolation prize', Tupolev was requested to develop a version of the Tu-14 (likewise powered by VK-1s) for the Naval Air Arm.

Table 1. Basic specifications of the IL-28

Length overall	17.45 m (57 ft 3 in)
Height on ground	6.0 m (19 ft 8¼ in)
Wing span	21.45 m (70 ft 4½ in)
Wing area, m^2 (sq ft)	60.8 m^2 (653.76 ft sq ft)
Wing loading, kg/m^2 (lb/sq ft)	288 (1,400)
Power loading at sea level, kg/kgp (lb/lbst)	3.38
Normal all-up weight, kg (lb)	17,500 (38,580)
Maximum all-up weight, kg (lb)	20,000 (44,090)
Fuel load, kg (lb)	6,300 (13,890)
Top speed, km/h (mph):	
at sea level	750 km/h (465)*
at 5,750-6,000 m (18,860-19,685 ft)	843 km/h (523)
at 10,000 m (32,810 ft)	820 km/h (509)
Landing speed	178 km/h (110)
Rate of climb, m/sec (ft/min):	
at sea level	10.9 (2,145)
at 5,000 m (16,404 ft)	8.3 (1,633)
at 10,000 m (32,808 ft)	3.6 (708)
Time to height:, minutes:	
to 5,000 m	8.6
to 10,000 m	22.6
Range, km (miles):	
with a 20,000-kg TOW, at 5,000 m and 542 km/h (336 mph)	1,815 (1,127)
with a 20,000-kg TOW, at 10,000 m and 546 km/h (339 mph	2,370 (1,472)
Endurance at 10,000 m cruising altitude and 546 km/h cruising speed	4 hrs 13 min
Take-off run, m (ft)	1,150 (3,773)/650 (2,132) †
Take-off distance, m (ft)	2,540 (8,333)/990 (3,248) †
Landing distance, m (ft)	1,730 (5,678) ‡

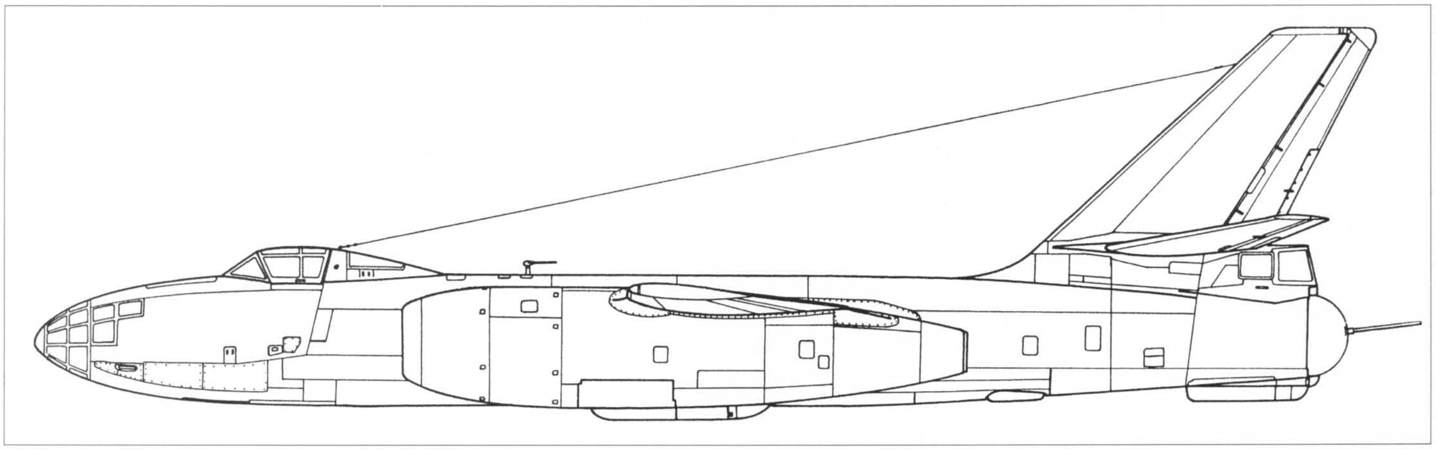
* Speed limited at altitudes up to 1,750 m (5,741 ft) due to the dynamic strength limit of 2,700 kg/m^2 (13,122 lb sq /ft).

† Without boosters/with two PSR-1500-15 JATO boosters.

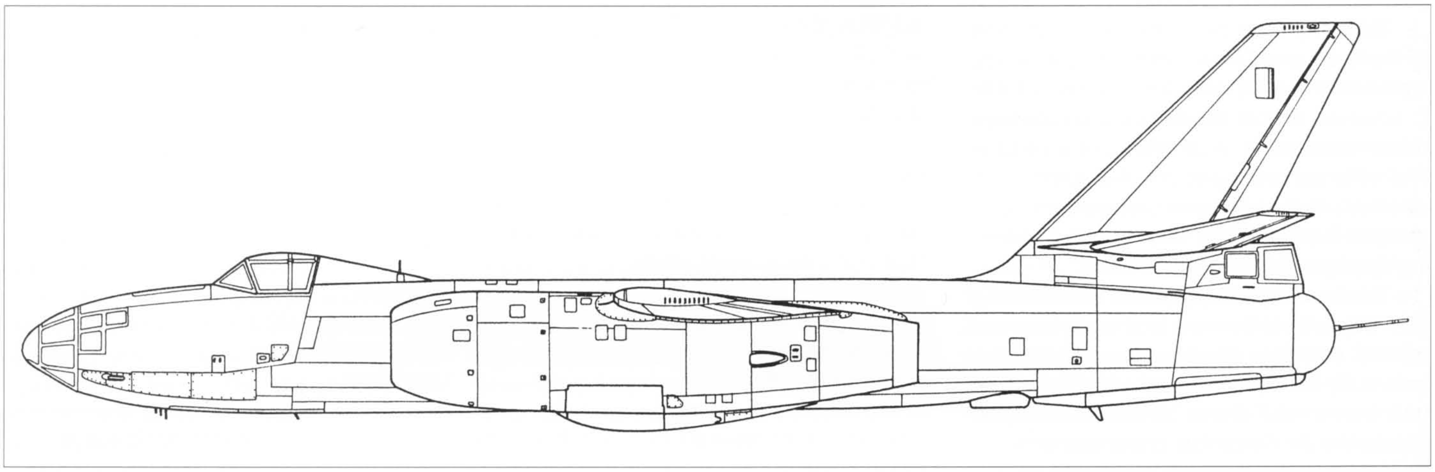
‡ With a 13,500-kg (29,760-lb) landing weight.

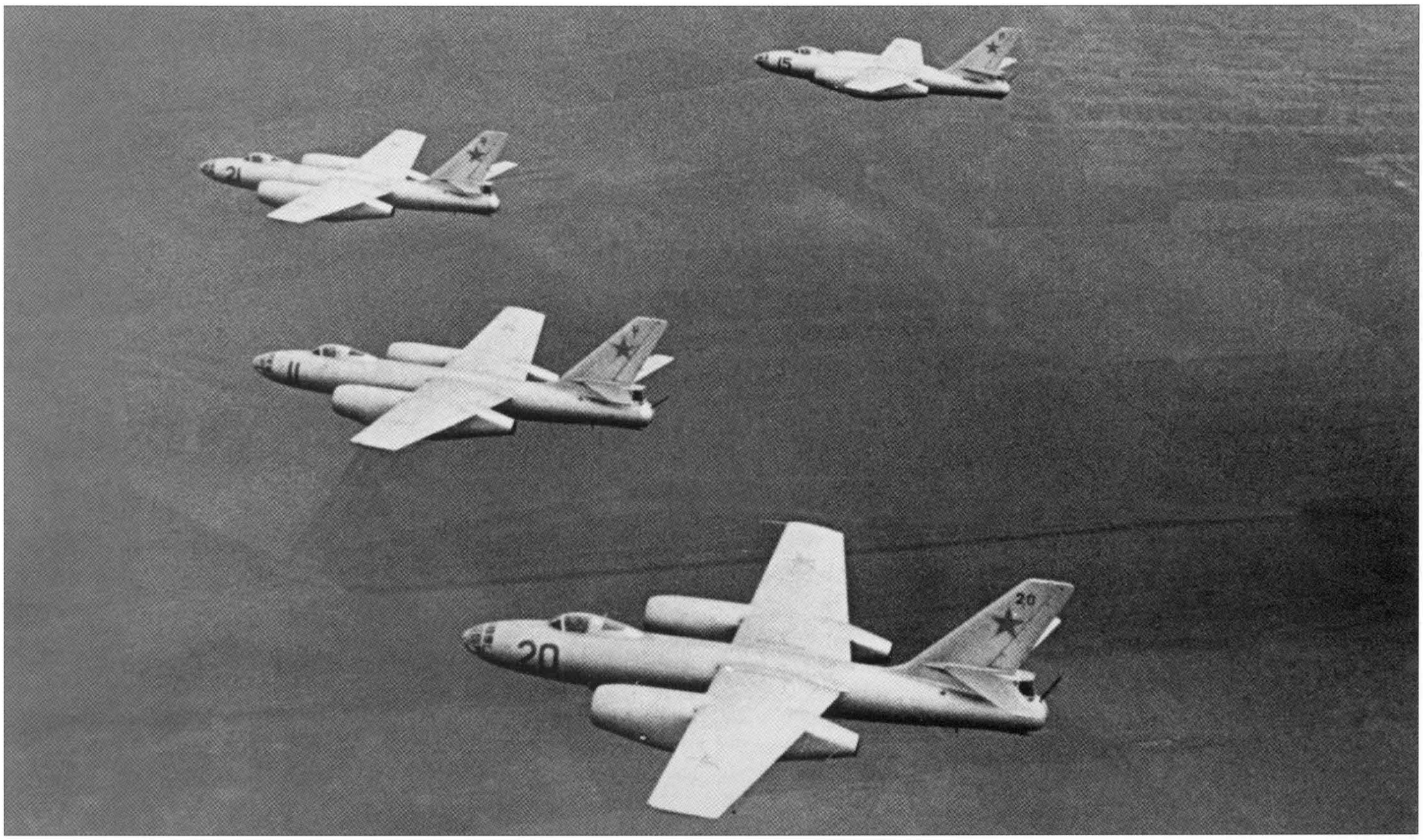
Table 2. Performance comparison of the IL-28 and Tu-14

	Tu-14	IL-28
Empty weight, kg (lb)	14,940 (32,940)	12,795 (28,210)
All-up weight, kg (lb):		
normal	21,000 (46,300)	18,400 (40,560)
in overload configuration	25,350 (55,890)	21,069 (46,450)
maximum	25,350 (55,890)	23,069 (50,875)
Top speed at take-off power/normal AUW, km/h (kts):		
at 5,000 m (16,400 ft)	845 (524)	893 (554)
at 10,000 m (32,810 ft)	811 (503)	850 (528)
Top speed at take-off power/maximum AUW, km/h (kts):		
at sea level	774 (480.74)	800 (496)
at 5,000 m	823 (511)	857 (532)
at 10,000 m	773 (480)	823 (511)
Service ceiling at normal AUW, m (ft)	11,200 (36,745)	12,300 (40,350)
Maximum range at 10,000 m/normal AUW, km (miles)	2,870 (1,782)	2,415 (1,500)
Take-off run, m (ft)	1,200 (3,940)	965 (3,170)
Landing run, m (ft)	1,100 (3,610)	960 (3,150)
Bomb load, kg (lb):		
normal	1,000 (2,205)	1,000 (2,205)
maximum	3,000 (6,610)	3,000 (6,610)

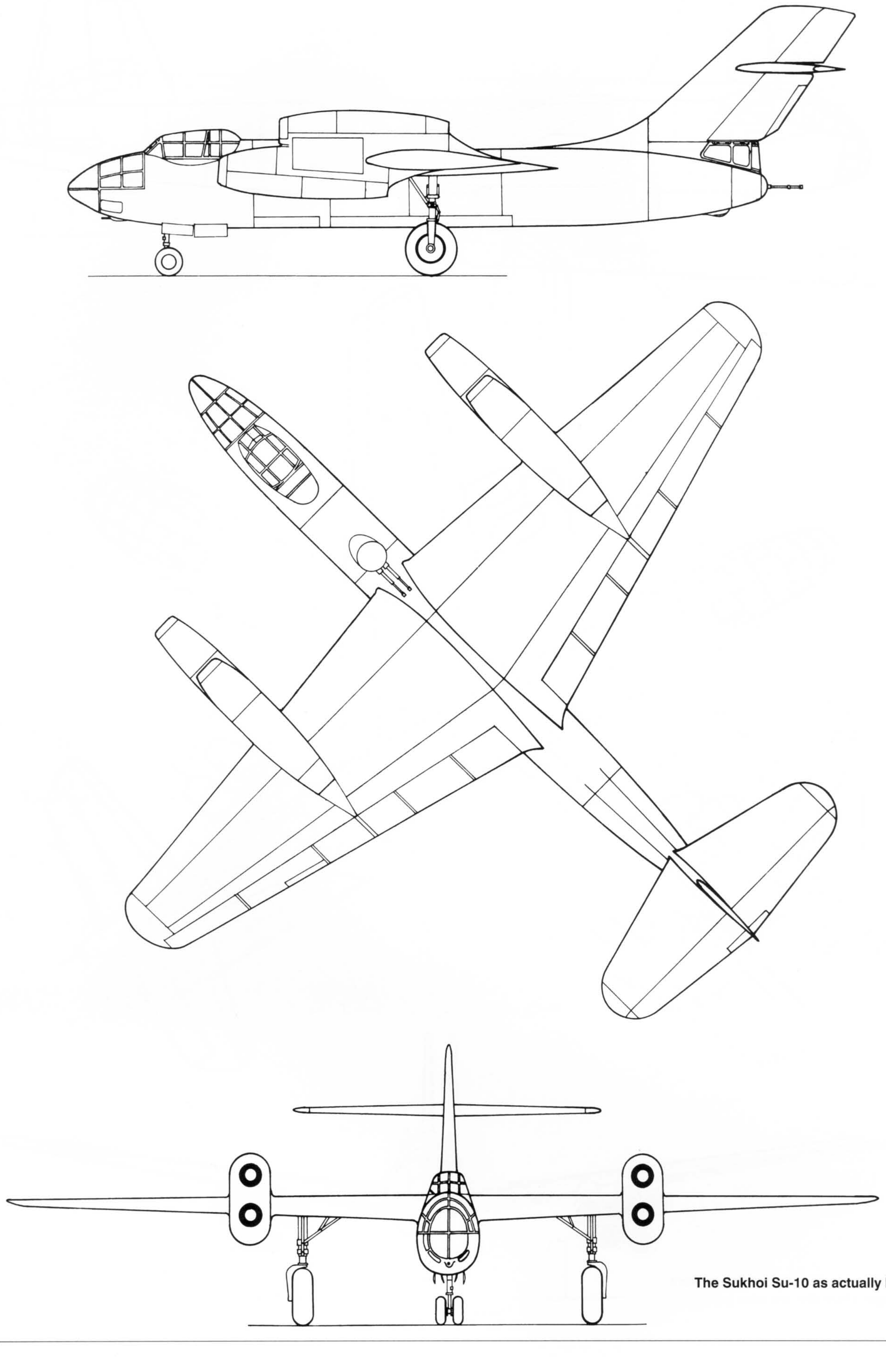


The first (above) and second (below) prototypes of the IL-28.

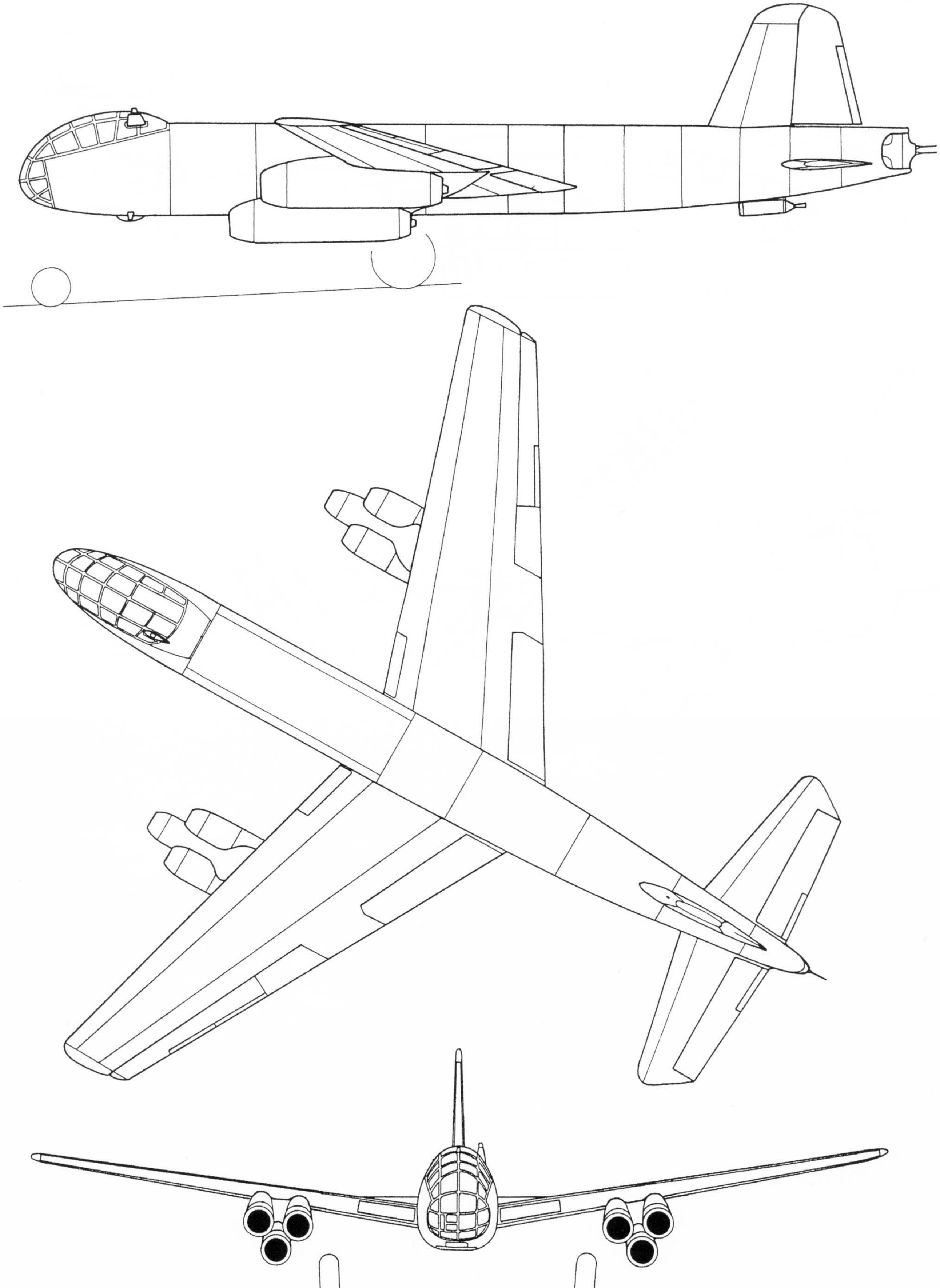




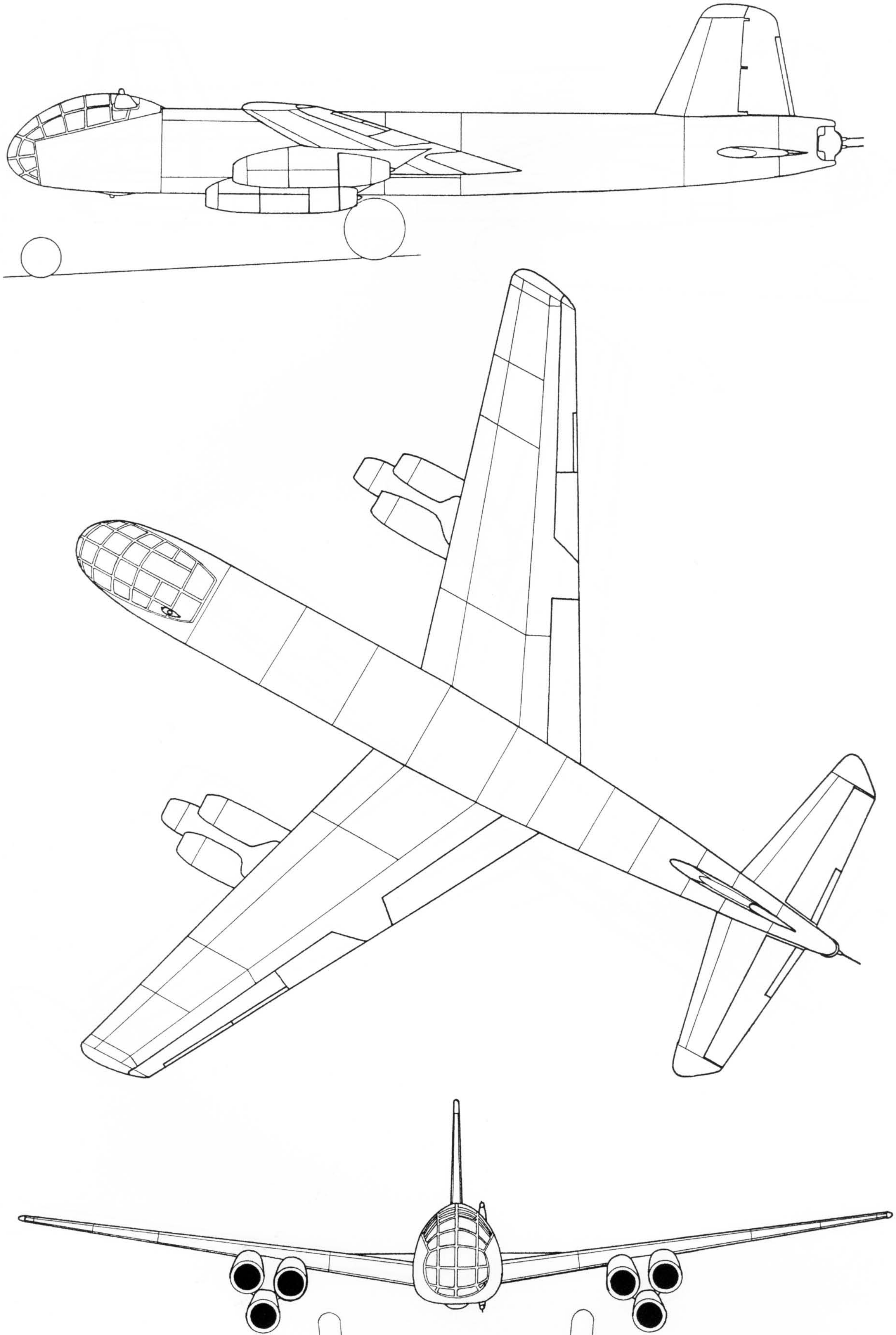
A formation of IL-28s. Note the revised cockpit canopy and navigator's glazing of the production version.



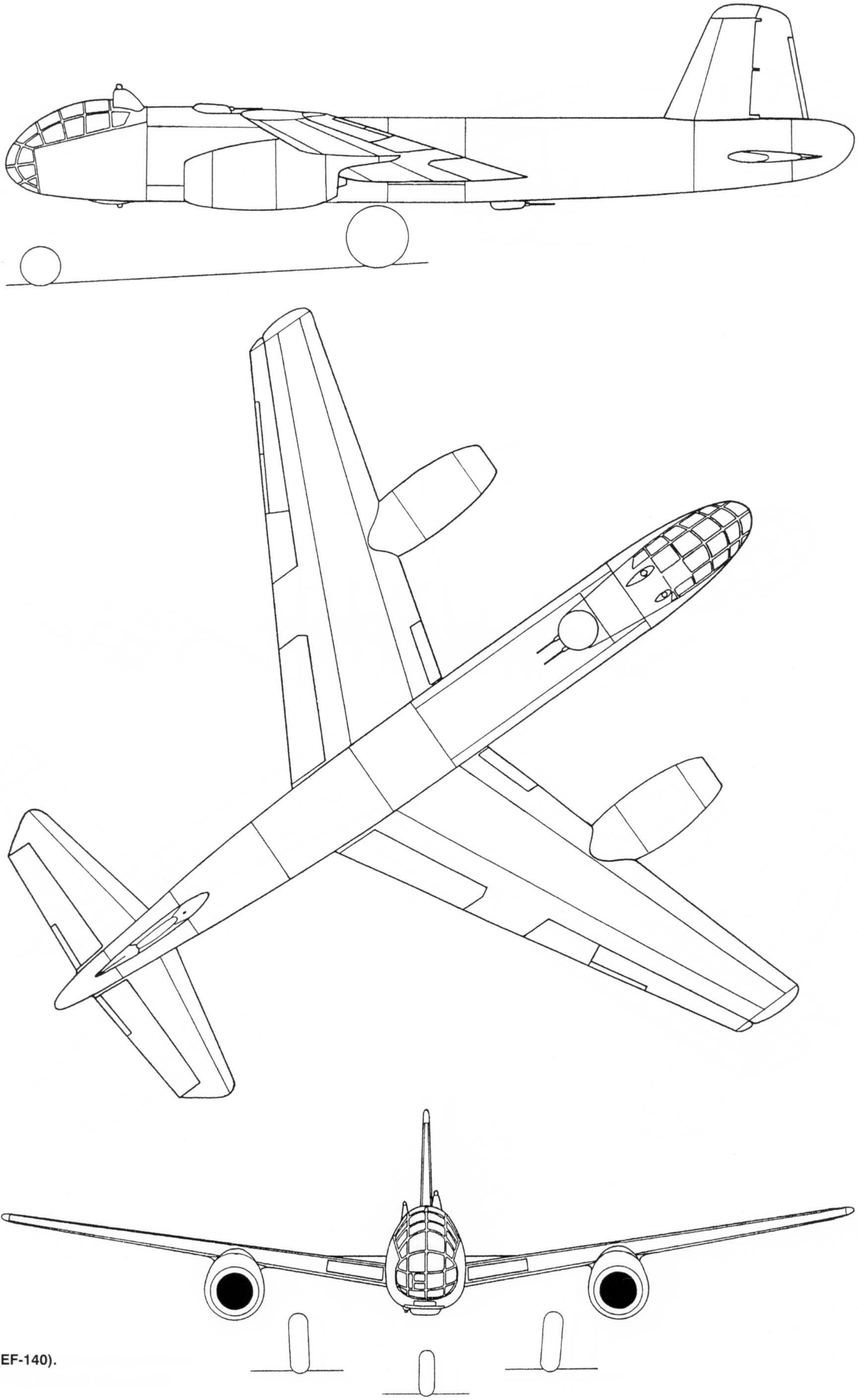
The Sukhoi Su-10 as actually built.



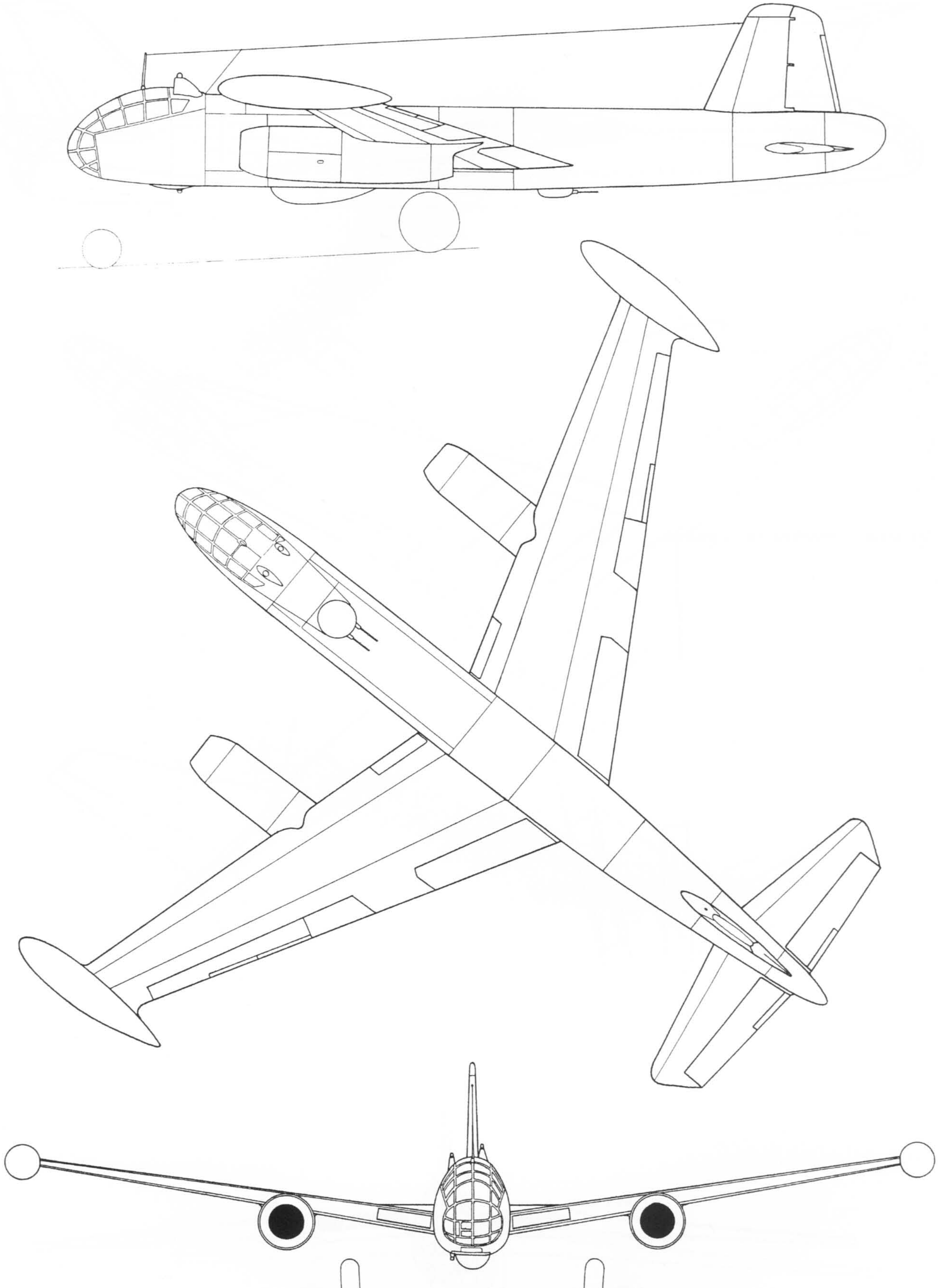
An early project version of the Junkers Ju-131.



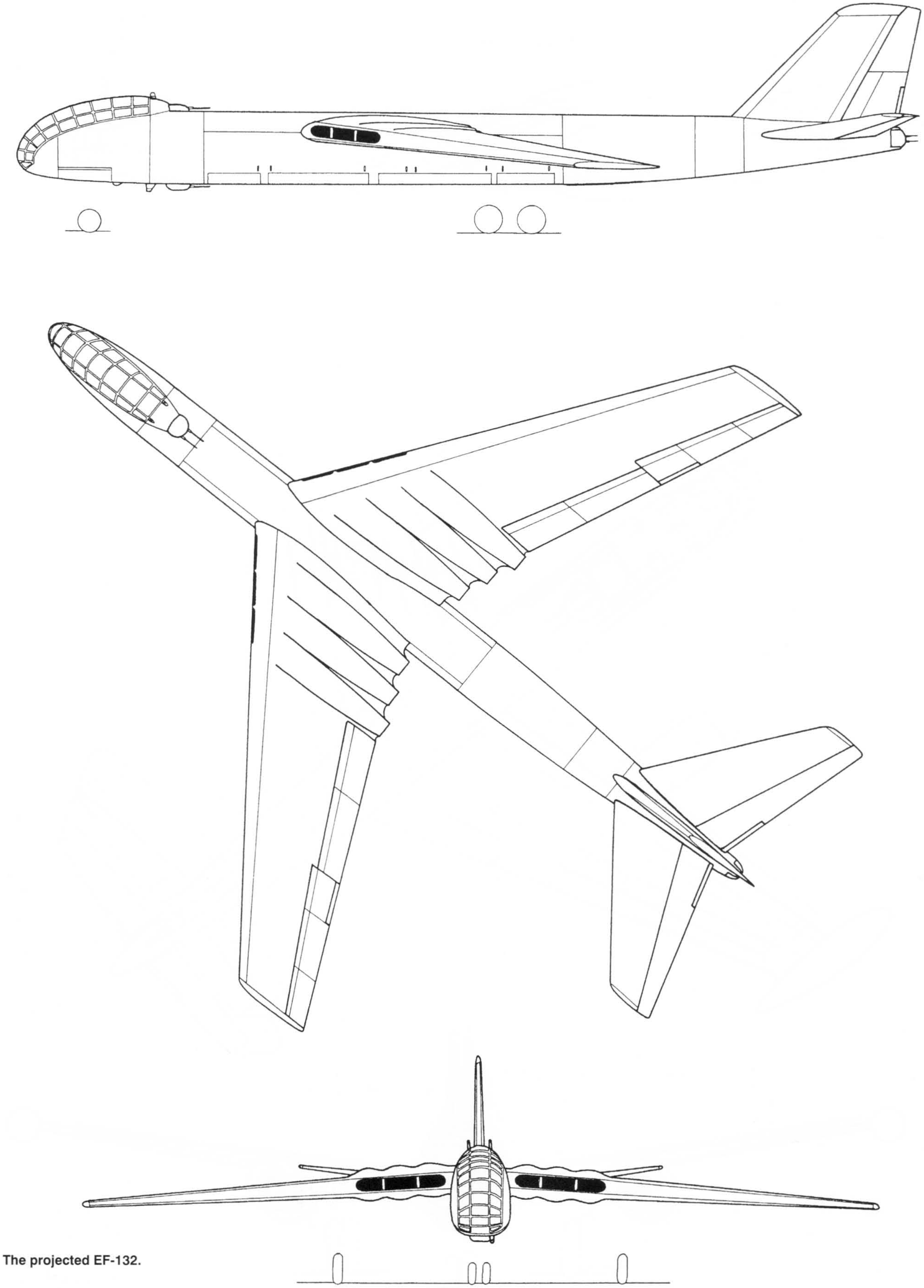
The Junkers EF-131 V1 as actually flown; note the different wing flaps.



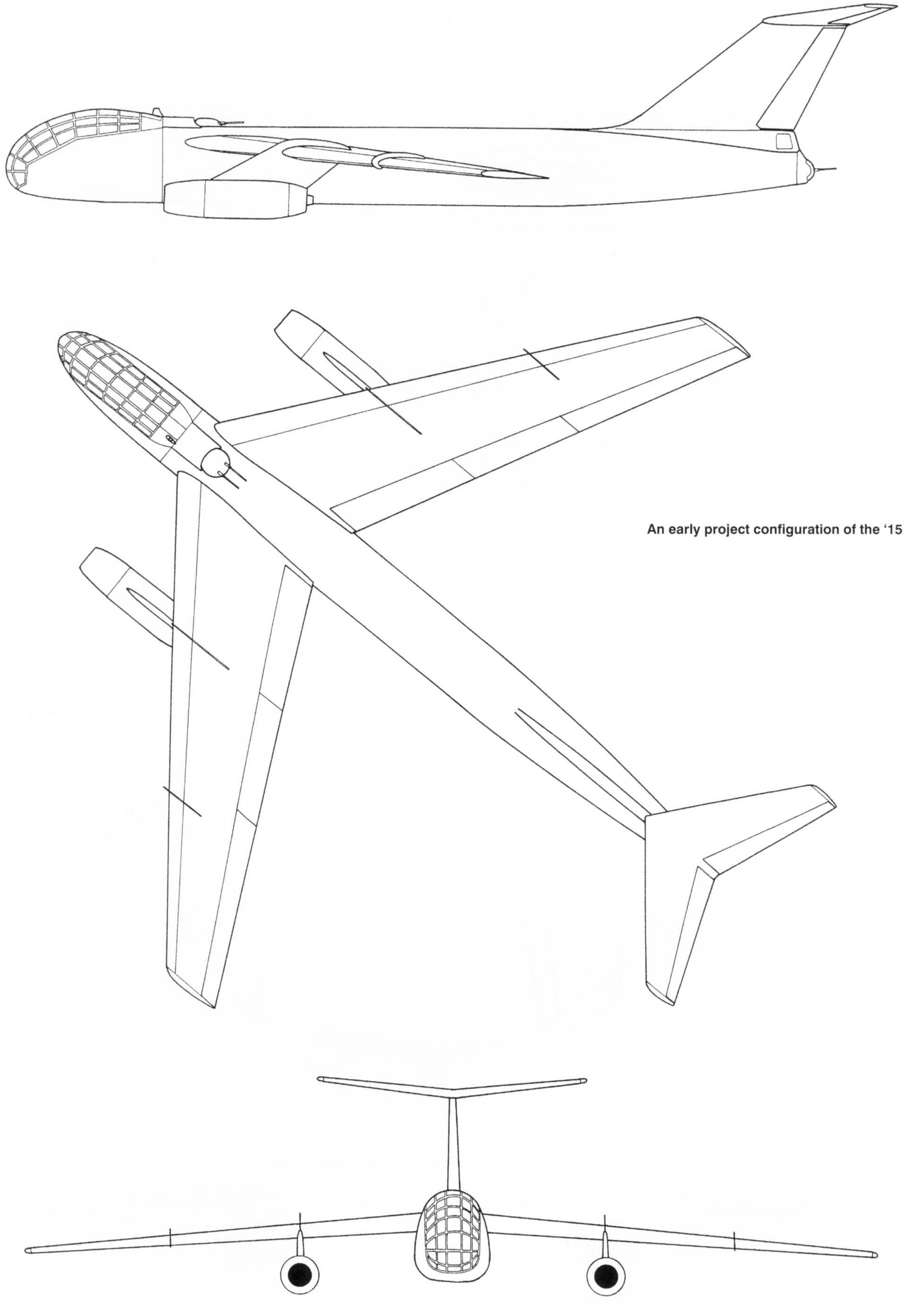
The '140' (EF-140).



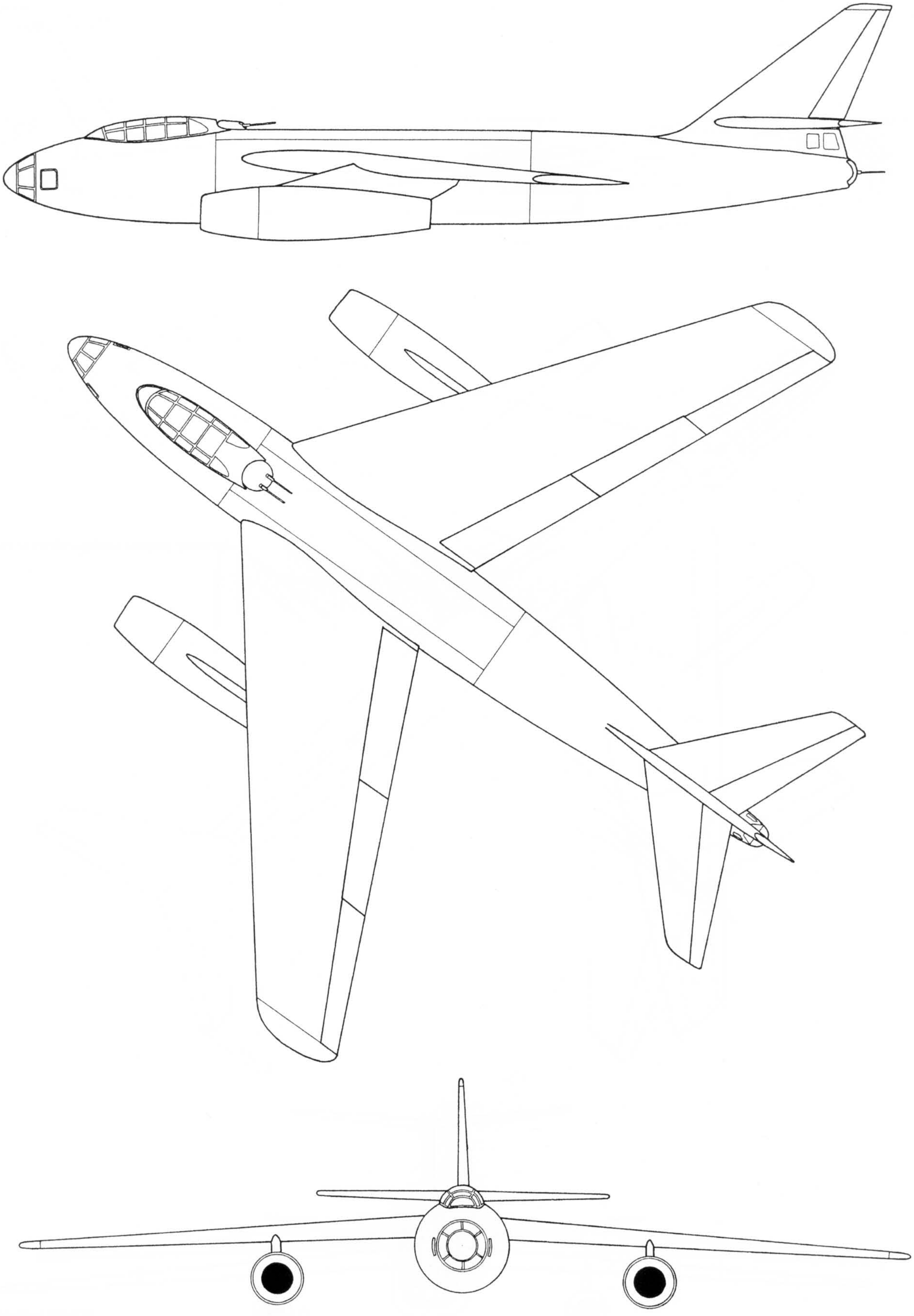
The '140-R'.



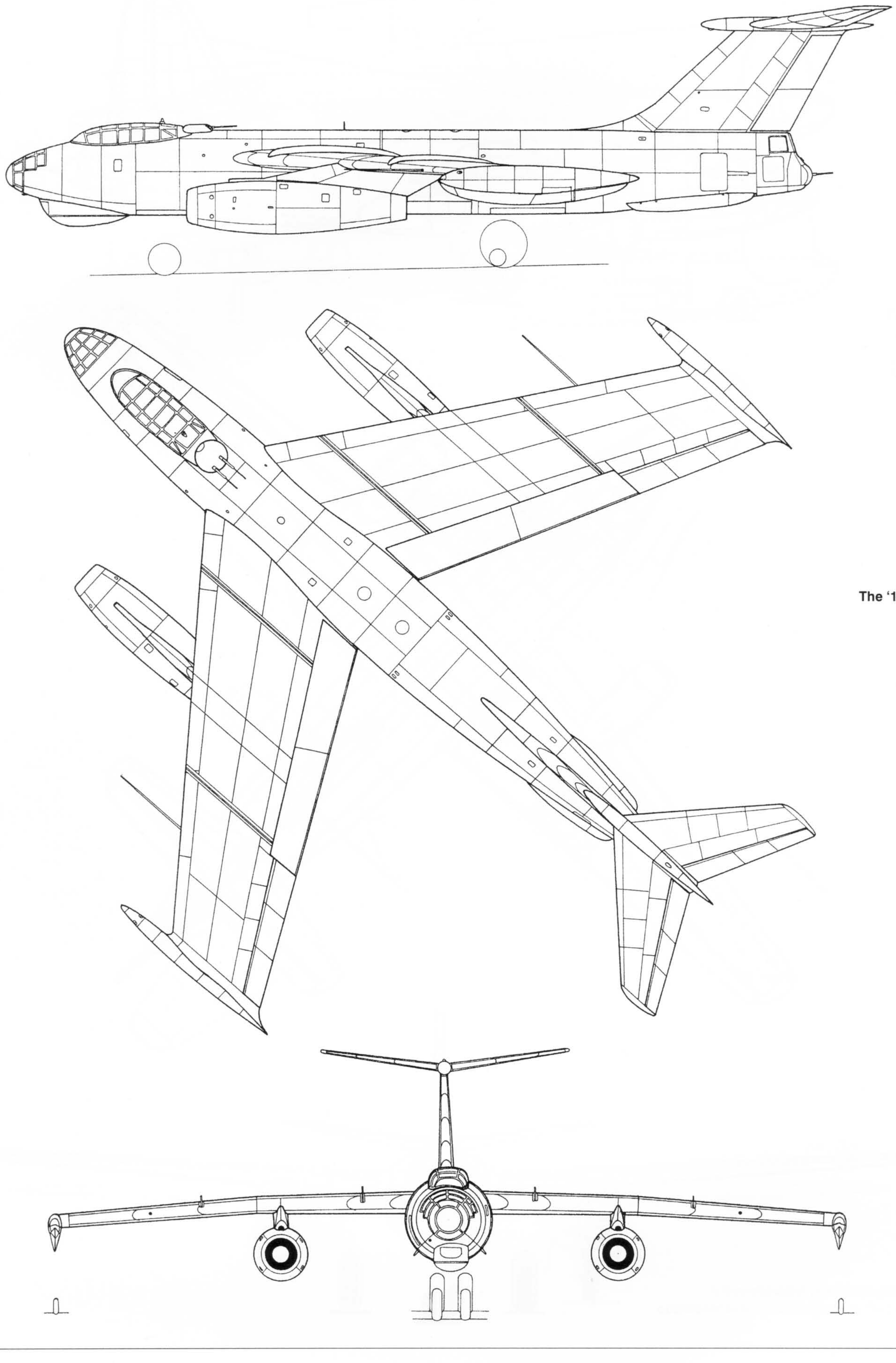
The projected EF-132.



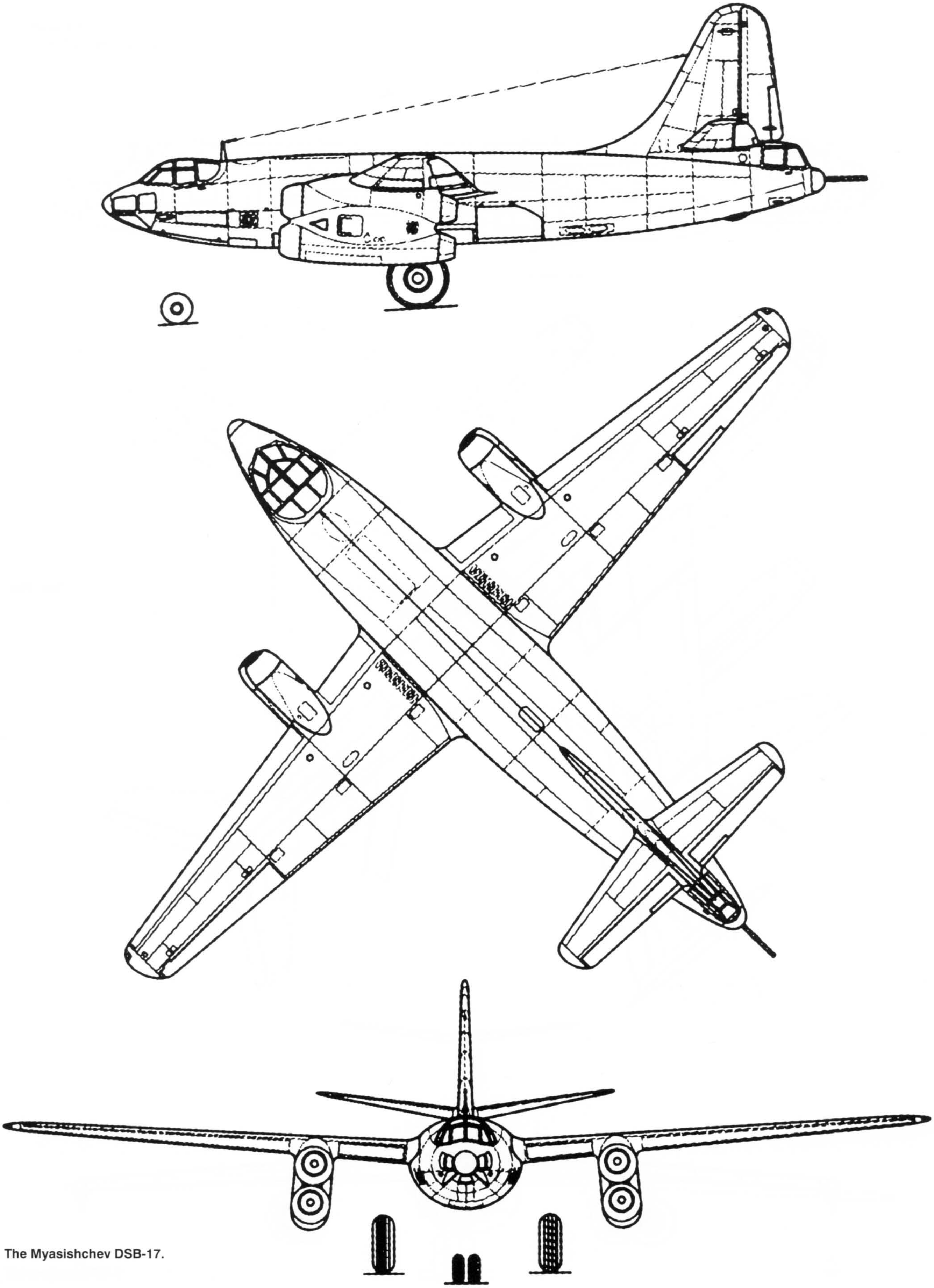
An early project configuration of the '150'.



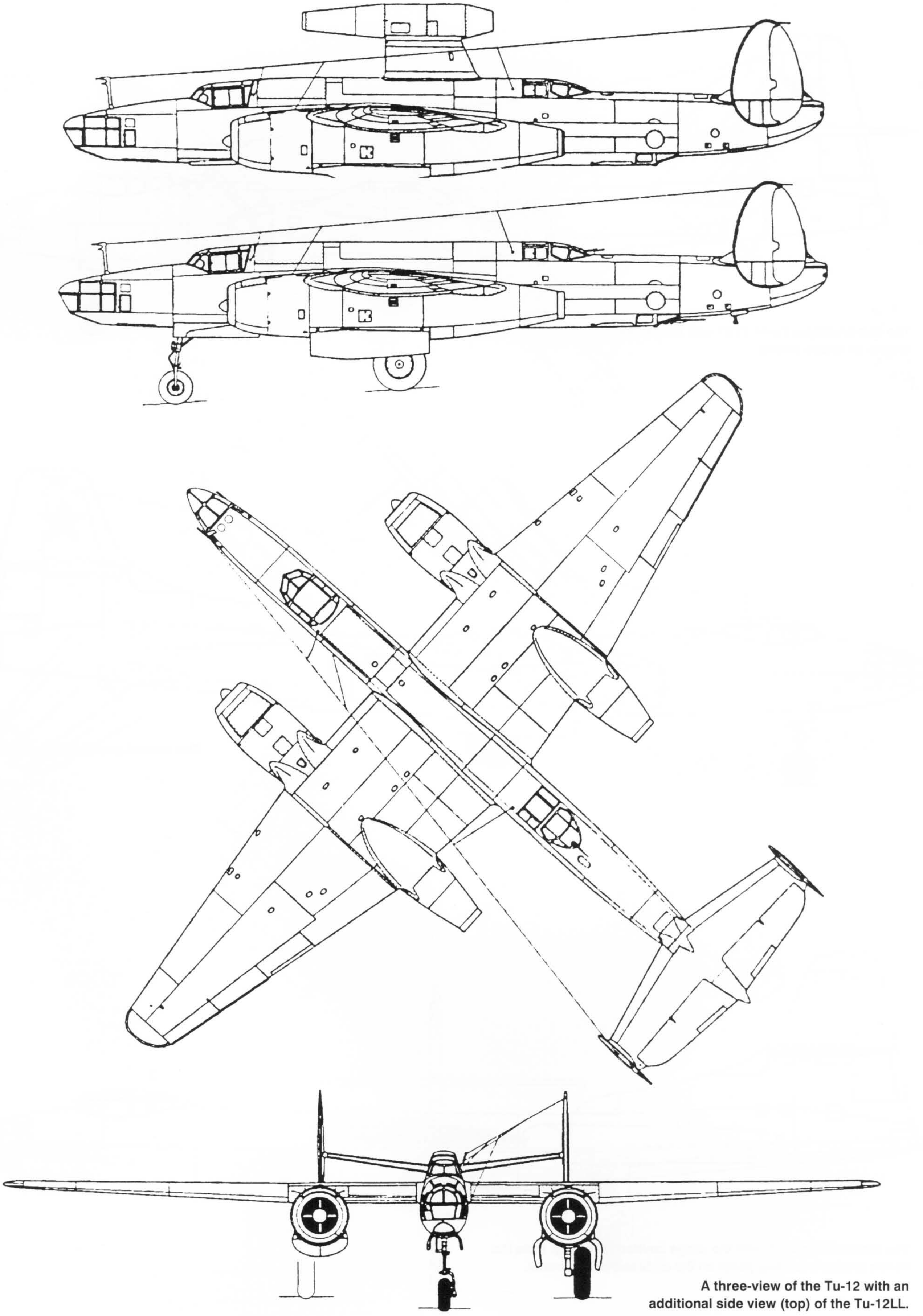
The projected RB-2.



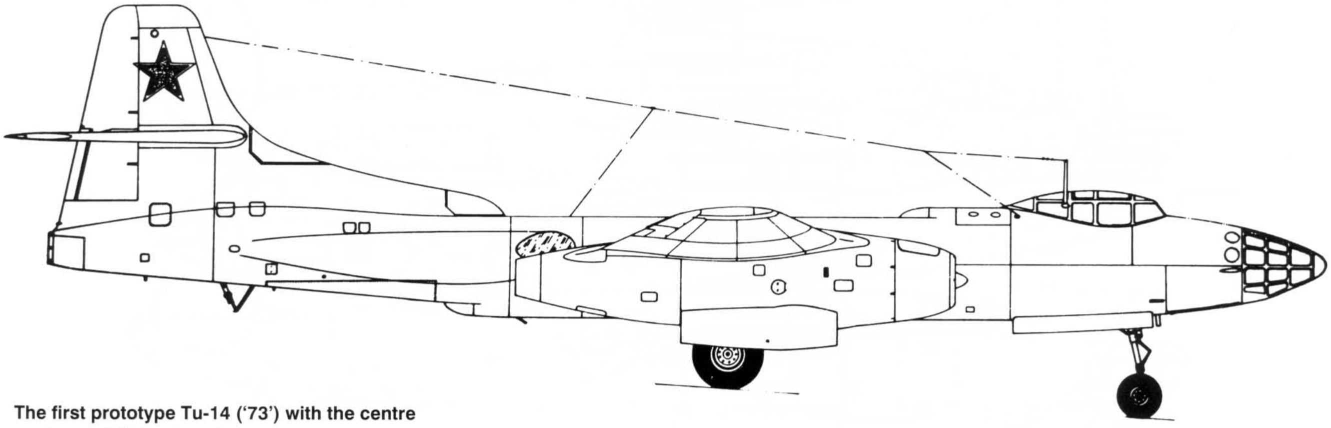
The '150'.



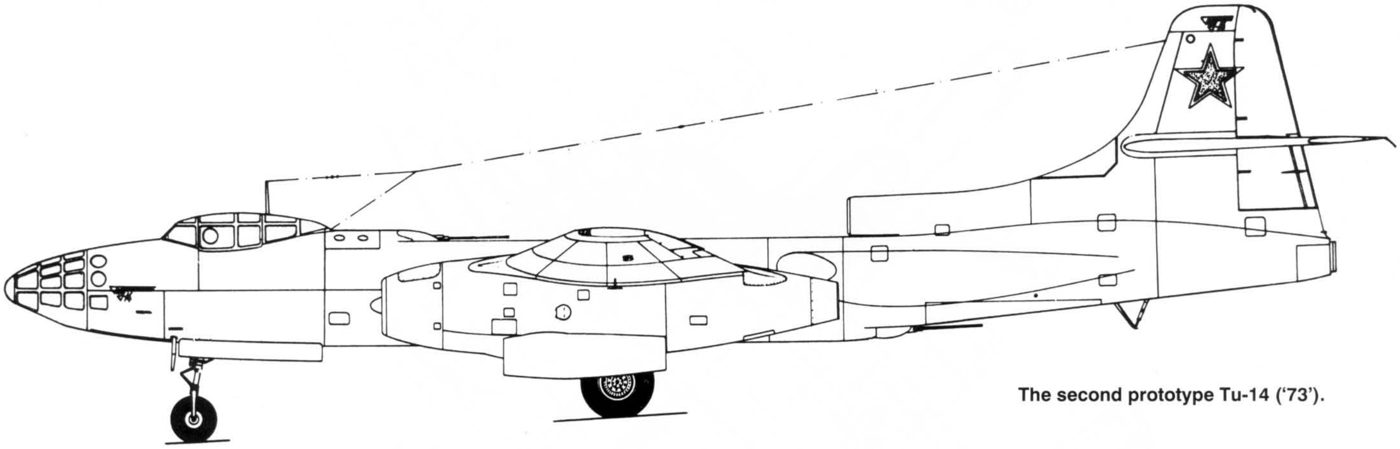
The Myasishchev DSB-17.



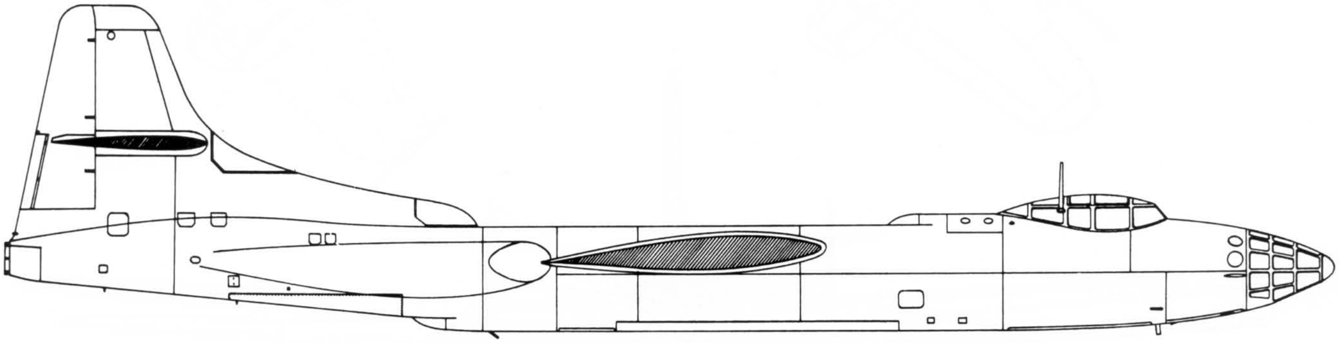
A three-view of the Tu-12 with an additional side view (top) of the Tu-12LL.



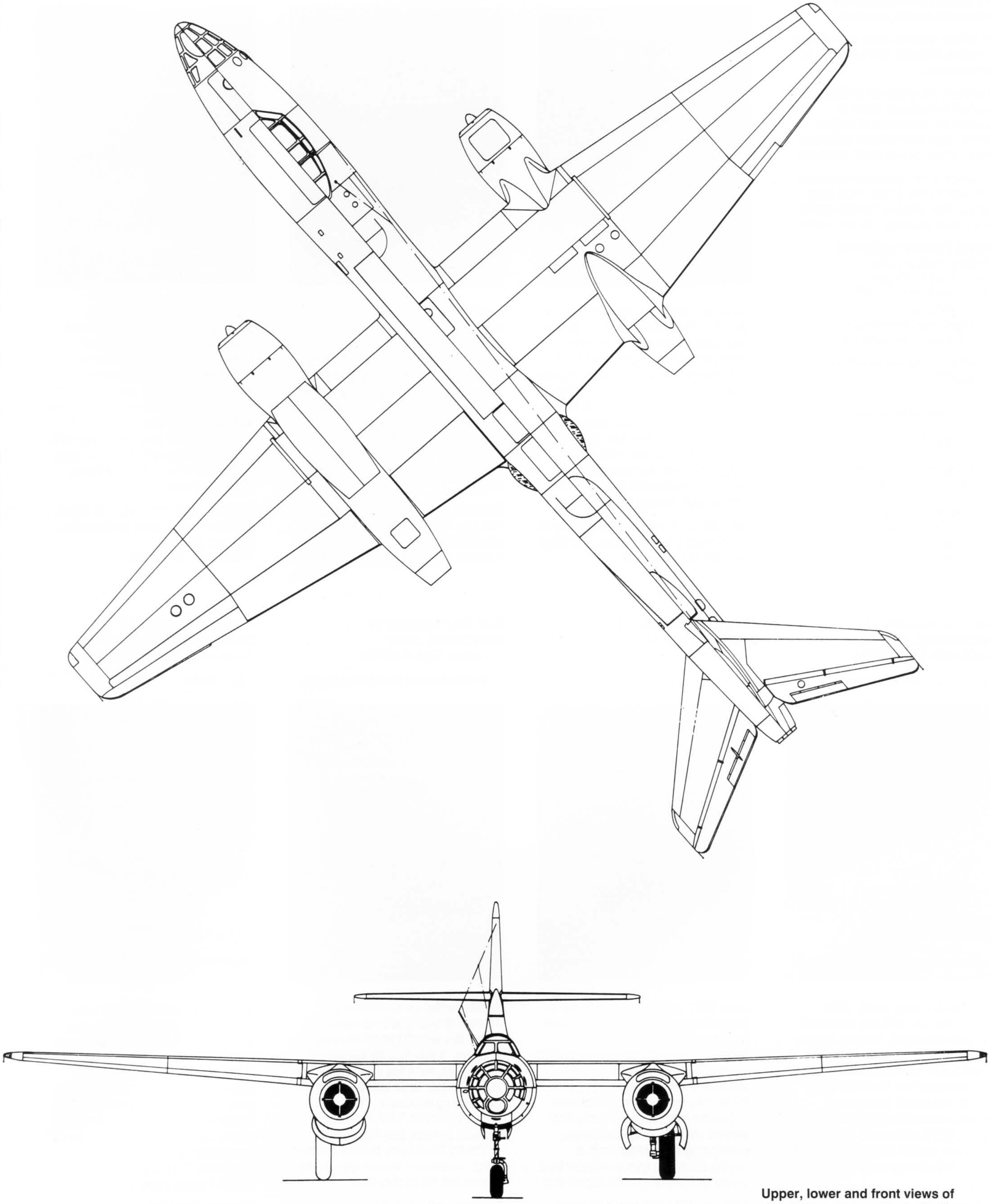
The first prototype Tu-14 ('73') with the centre engine air intake closed.



The second prototype Tu-14 ('73').



The first prototype '73' with the wings omitted for clarity. Note the centre engine's cowling panel on the aft fuselage underside.



Upper, lower and front views of the first prototype Tu-14 ('73').

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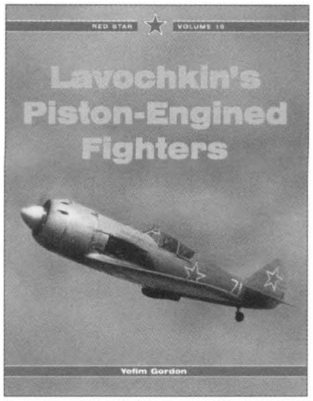

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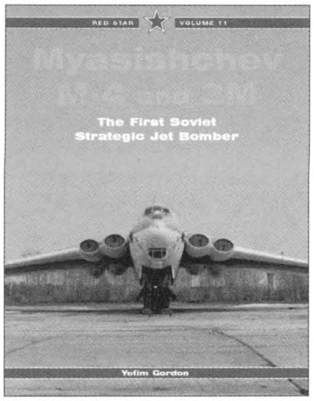

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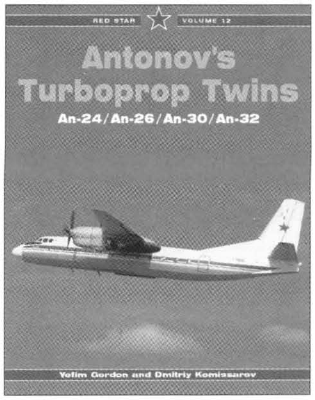
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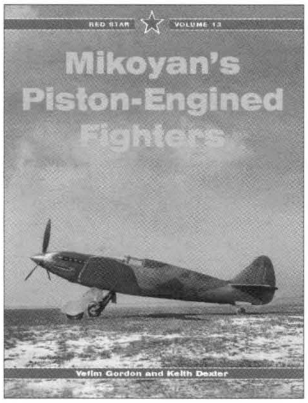
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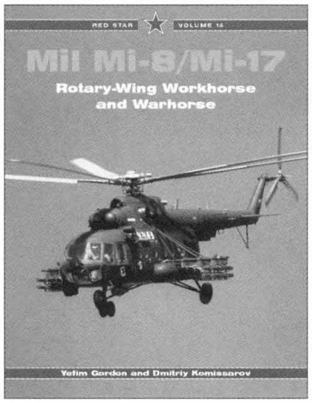
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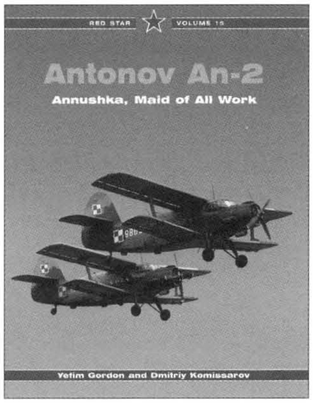
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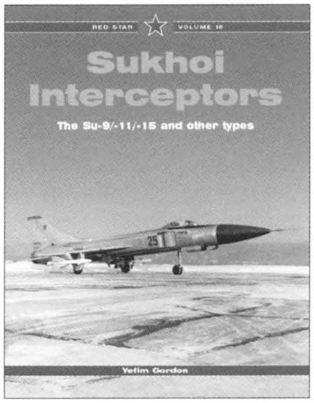

From 1953 Sukhoi produced a line of delta-winged interceptors including the Su-9 in 1958 followed in 1959 by the T-47/Su-11. A new line was started in 1960 with the twinjet T-58 which entered production as the Su-15. This aircraft remained a key element of the Soviet Air Defence Force well into the 1980s. Various versions of the Su-15 are detailed, as are the experimental PT-7/PT-8, T-49 and the unusual two-seat P-1 heavy interceptor.

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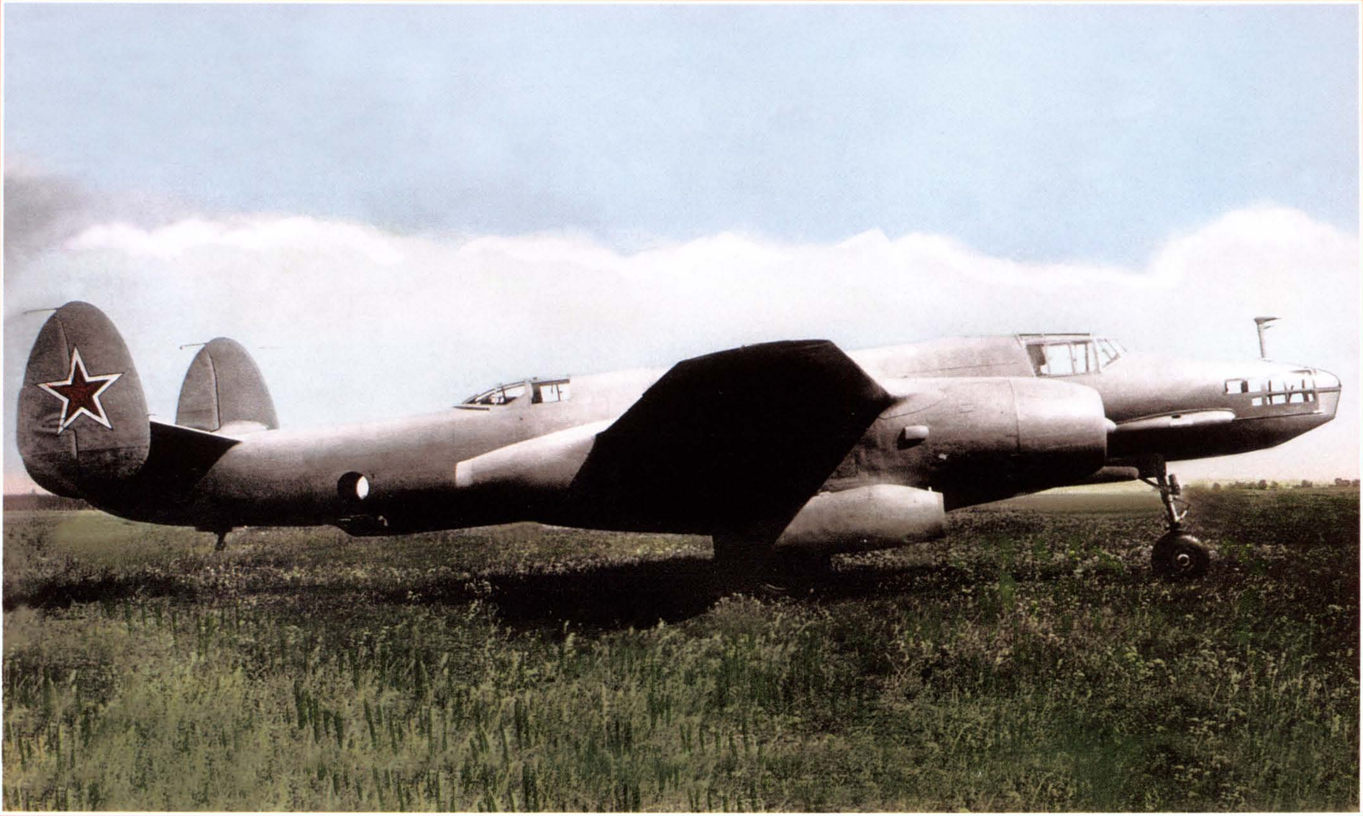

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